Popular Astronomy.

Vol. XXVIII, No. 2 FEBRUARY, 1920. Whole No. 272

VARIOUS SUGGESTIONS RELATING TO STELLAR EVOLUTION, PLANETARY GENESIS, AND HYPERBOLIC COMETS.

By WILLIAM H. PICKERING.

In my original paper on the phenomena presented by a Nova (POPULAR ASTRONOMY, 1918, **26**, 599), it was explained that the displaced absorption lines were due to a cool, comparatively dark, cloud of gas receding from the star. In twenty-four hours this cloud or shell, according to the figures given by Professor Adams (Com. Nat. Acad. Sciences, **55**), would recede to a distance of 130,000,000 to 200,000,000 kms. Only a small section of it therefore would, as he points out, be projected on the star, and the lines, as distinguished from the bright bands, would consequently be narrow, as is found actually to be the case. He mentions however a very curious fact. In the four most recent bright novas, the dark lines were double, and the displacements observed were very closely in the ratios 1, 2, and 3. It would appear therefore that the explosions generating these high velocities can only occur at certain speeds, the lowest being at 750 kms per second, or exactly 1/400 the velocity of light. This is just twice the maximum speed observed hitherto in the Sun. Taking 1/400 as our unit velocity, in one pair of novas the recession of the shell of gas was at speeds of 1 and 2 units, and in the other and brighter pair the velocities were as 2 and 3 units, the highest speeds for each pair occurring only in the case of hydrogen and helium.

It appears therefore that the projecting force must be due to a decomposition, and change of structure in the interior of the star, rather than to a mere escape of gas under high and varying pressure. Since by molecular decomposition we have only been able to produce speeds hitherto of between one and two kilometers per second, and since such molecules certainly cannot exist in the interior of a star, it would appear that the decomposition must be atomic. We conclude therefore that atoms can be rapidly decomposed and destroyed under sufficiently high temperatures and pressures. Perhaps the greatest problem of the physical universe is to determine how they can be reconstructed,—possibly under extreme pressure and cold. Since a small but definite acceleration of motion was noted, it is clear that a con-

tinuously acting repulsive force, as in the case of cometary tails, slightly exceeded the attraction due to gravitation.

If the Sun itself was formerly a nova, we can understand that the rapidly receding shell of the lighter elements might later condense to form our larger planets of small specific gravity, while the second and less rapidly receding shell of the denser elements would condense to form the terrestrial ones. The colors exhibited by the disk of Jupiter naturally suggest the oxides of hydrogen and nitrogen, while the brilliant second ring of Saturn suggests snow, or one of the frozen gases. The banded spectra of four outer planets (Lowell Observatory Bulletin No. 42) are in urgent need of interpretation by some spectroscopic expert. Suggestive photographs of planetary nebulae by Pease taken with the 60-inch reflector, are given in Cont. Mount Wilson Sol. Obs. **132**, Plates 6 and 7. Four of these are represented in Plate III. Figure 1 shows what appears to be a hollow spherical shell of gas condensing into irregular luminous masses. Figure 2 shows an inner ring already formed, while various individual masses are condensing out of the outer one. The two rings lie approximately in the same plane. Figure 3 shows three rings all lying in different planes. A bright planet or companion has already condensed in one of them. Judged by its slightly elongated form as compared with the nucelus, it is not yet quite spherical, and may be rapidly rotating. Figure 4 also shows three rings, the middle one very narrow and inconspicuous, and lying just outside the inner one. They both appear to be quite eccentric.

Determinations of the parallax of six planetary nebulae have been made by Van Maanen (Com. Nat. Acad. Sciences **56**), who finds that the absolute magnitudes of their central stars range between 6.7 and 10.4,—mean 9.1. In no case therefore are they as bright as our Sun, 4.75, and their average luminosity is but 1/50 as great. The mean velocity of these objects is found to be 29 km per sec., which is higher than that of most stars. It has been suggested, on account of their spectra, that they develop into Wolf-Rayet stars, which are much more luminous bodies, moving with slower speed. It is possible that in the galactic regions where these objects are found non-luminous nebulous clouds exist, which by diminishing the speed of the planetary nebulæ account for their increase in luminosity.

As Van Maanen points out, these nebulae are enormous bodies. They are also very remote. In the various photographs by Pease, the nearest approach of a distinct ring to the central star occurs in the cases of nebulae N.G.C. 7009 and 7662, shown in Figures 3 and 4. In both these cases the separation is 3″.8. If the ring were closer than that to the star, it could hardly be distinguished as such. The nearest planetary nebula that Van Maanen has found, N.G.C. 7662, has a parallax of 0″.023. If the Earth were removed to that distance from the solar system, the distance from the Sun of a ring filling the orbit

of Neptune would appear to be 0".69, and in order for us to be able to photograph it, it would have to be removed to 5.5 times the distance of that planet.

Therefore if these nebulae contained rings at our planetary distances we should not be able in any case to detect them. However, if rings can be thrown to a great distance from a star, there is no reason why they should not sometimes be thrown to a less distance. Moreover, if these rings break up into planets, as these photographs seem to indicate, and if these planets revolve in a resisting medium, or meet other revolving fragments, such as are perhaps shown in Figure 1, there will be considerable lost motion, and the rings will necessarily contract, and at the same time, as shown by La Place, become more nearly circular. Not only planets, therefore, but remote companion suns, visual binaries, might sometimes be formed in this manner.

Leaving now the discussion of photographic details, and returning to the fundamental proposition that the cause of a nova is due to the collision of a star and a planetoid, let us see what corroborative evidence we have of the existence of these latter bodies. Besides the requirements of the planetoidal theory, there are of course the asteroids, —actual planetoids attached to our sun, and the two brilliant colliding bodies observed by Carrington and Hodgson in 1856 (POPULAR ASTRONOMY, 1918, **26**, 606). We have found that the existence of a wandering planetoid would explain the birth of our Moon. Then there are the comets. Most of these are simply meteor swarms accompanied by a gaseous atmosphere, but occasionally one is seen with a bright stellar nucleus which appears to be a really solid body, like an asteroid. While most comets have very eccentric orbits, that of Holmes amounts only to 0.412, and the orbits of several others have less eccentricity than that of the asteroid Albert, 0.541. Their masses, though unknown, must be similar to those of the asteroids, and should a comet furnished with a well defined nucleus be captured by Jupiter, and in the process of time gradually lose most of its gaseous envelop, there would be little or nothing left to distinguish it from an ordinary asteroid. If all the asteroids were formerly comets, it is clear that most of these latter bodies are of much smaller mass than the assumed planetoid of 1000 miles in diameter.

Of the millions of comets, however, which must have been captured by Jupiter during the past thousand million years, it is very evident that only a fraction of one per cent have been converted into asteroids. The remainder must have been dispersed as meteoric dust, and irons of small dimensions. Much of this material has been driven away by light pressure, some has been captured by the asteroids, and some is left to appear to us as the zodiacal light, the zodiacal band, and the gegenschein. In the mean time it has served as a resisting medium to reduce the eccentricity and mean semi-diameter of the orbits of those

asteroids which earliest became regular members of our system.

The cometary orbits are continually shifted by the larger planets, especially Jupiter, and three have passed pretty near the solar surface within recent times, two, those of 1843 I and 1880 I within 80,000 miles of it, while the center of the third, that of 1668, at perihelion was within a distance of 13,000 miles, as nearly as can be determined from the observations of that date. If these observations are correct, the surfaces of the Sun and comet must have come pretty near scraping. On the other hand comets are at times unquestionably thrown out of our system by the larger planets. They must then traverse interstellar space until they reach another star, and if furnished with sufficiently large nuclei become true planetoids. Similar comets, comets with hyperbolic orbits, must of course reach our system from the stars, but unless they chanced to pass within the orbit of Mars, which would only occur at rare intervals,we should hardly become aware of their presence. Most of them would come to perihelion beyond Neptune, and only very rarely would a swiftly moving one come any nearer. If moving at much more than parabolic speed with regard to the Sun, it would have to be pointed very directly at it in order to pass near us. It is only therefore from those stars that are moving in nearly the same direction and with the same speed as our Sun, that we are likely to receive visible comets.

Besides these bodies there is still another instance casually mentioned in POPULAR ASTRONOMY, 1918, **26**, 606, where the existence of planetoids seems now to be rather urgently required. Stars are known of types M and N, whose density is less than one twenty-thousandth that of our Sun, or about one twentieth that of our atmosphere at sea level. If gaseous, such bodies are difficult to understand. Let us picture to ourselves such a white hot star, of the same mass as our Sun, and of 27 times its diameter. The force of gravity on its surface will be 1/730 as great, or one twenty-sixth of what it is on the surface of the Earth, and one quarter of what it is on the Moon. The Moon, as is well known, even though a cool body, cannot retain an appreciable atmosphere. Whatever atmosphere it has is constantly escaping, and constantly being replaced from its interior. Therefore if these white hot stars are really gaseous, they must be rapidly dissipating into space, and as they diminish in size they must still more rapidly disappear. Instead of growing hotter by compression, they must actually be growing cooler by evaporation.

If on the other hand they are built up of a swarm of planetoids, frequietly colliding with one another and constantly generating a heated atmosphere as the result, we should have a permanent body gradually diminishing in size, and radiating heat and light in all directions. A swarm of several hundred million planetoids, each 1000 miles in diameter and averaging 50,000 miles apart, could hold itself together,

a swarm of meteors would do the same, although it could hardly become or remain hot, as the planetoids would do. A mass of hot diffuse gas could not exist as a single isolated body under any circumstances.

Mandeville, Jamaica, B. W. I., November 6, 1919.

FIRST STUDY OF HEAVENLY BODIES.

By MARY E. BYRD.

LESSON II.

Thirty-odd years ago, I was the recipient of rather an unusual set of letters. There was one from every member of the class just beginning astronomy at Carleton College. All had the same theme: "What I know about the Moon." They made interesting reading, were short, ingenious, not unduly burdened with fact, and contained some surprising pieces of information, though it was left for an eastern college student to intimate broadly that the moon stays always in the same constellation!

This year, were it my good fortune to meet a class of beginners in astronomy, my request would be, not for confessions of ignorance, but for programs of hope, and the subject for letters should have some such wording as this: "What I mean to Learn about the Moon with my own Eyes."

With a similar aim, barring for the present optical aids and printed matter, except almanacs and maps, let us make out our first working list for the moon. It calls for little time in the study, for its making naturally goes hand in hand with observing. So if a few points are fixed in mind that suffices when we give "the first watch of night" to the changing moon. Conditions are, perhaps, most favorable when the young moon in the west holds the old moon in her arms. There is no need then to cudgel the brains for questions; they come of their own accord. Are all parts of the crescent equally bright? Is its color pale orange, yellow, or silvery white? Do the dark and illuminated portions appear to belong to the same or different circles? If the latter, which part belongs to the larger circle? Is the line between them smooth or broken? Which way do the horns point in reference to the sun, now beyond its setting point, below the horizon? Ah, how quickly time passes when the moon is getting low. Will it disappear behind the big elm tree whose topmost branch it is approaching, or go down back of the distant church to the right?

The last part of the observation often partakes of an adventure.

The bright star so close to the moon, can it be identified before both set or before the electric lights flash out? And what of the clouds? They can gather so swiftly and ingulf in darkness a whole quarter of the heavens. Even a little one may obscure the setting point of any body, and we breathe freer when the horizon line holds clear till the moon is safely by. And yet whenever its going, it seems too soon, as if the curtain had dropped before the play was over. We wanted to find out whether they were moving apart, the moon and star, or coming nearer together. And was the star really a star or a planet? Nor was careful note taken of the cusps, whether they were equally sharp or one blunted. Many things are left for other nights.

A brief hour with the moon does more than much reading to show how closely the heavenly bodies are linked together. Their story, lettered above in blue and gold, cannot be read piecemeal. It is not possible to take up one celestial object, finish with that and pass on to another. As just seen, in finding how the horns of the moon point, it is desirable to know where the sun set, and if its course is followed a little while before setting, it will not be necessary to search over a wide expanse of bright sky for the slender crescent, but only to look along the path the sun has just traversed; for the very term, new moon, means that the moon is near the sun. While it is convenient, for minor points like these, to take account of both sun and moon, results of more value are obtained by determining their diurnal paths on the same day; and if a planet's path and one of a star are included, on or near the same date, the observations mean more, and yield more than the most painstaking investigation of each path separately, a truth that appears very clearly as soon as the plotting and discussion of data are undertaken.

When we turn from motions referred to our own horizon to movements on the celestial sphere, the stars are all-important, and the zodiacal constellations should be known as well almost as ones own name; for, year in and year out, it is along the broad highway of the zodiac that sun, moon, and planets travel. Just where the moon makes this journey is one of the next problems. It is not the easiest object to follow among the stars. At its first and last appearance, it is seen as a tiny crescent low in the west or east, against so bright a sky, that often no stars are visible near by. Some two weeks later it is well placed in altitude, after twilight has ended, but then its own light puts out many stars, especially those suited for reference. Perhaps as favorable a time as any is midway between new moon and first quarter, though the following observation was taken a little later:

Fort Lyon, Colorado, Saturday, Nov. 29, 1919.

"At $5^h\,45^m$ p. m. the moon was in line with θ Pegasi and α Aquarii, and also equally distant from α and β Aquarii." W. V. C.

Reference toMap IV of Young's Uranography shows that the moon

when observed was in Aquarius (note that this is a zodiacal constellation) and plotting locates it near the place obtained by checking from the American Ephemeris. If two positions are fixed as above, the direction and rate of the moon's motion are readily determined; and it is a white-stone day and a happy student when five positions, separated from one another by only a few days, can be counted in the same lunar month.

The astronomer's almanac, the American Ephemeris, just mentioned, is often convenient for reference, and should be found in any public library.

The crescent moon and the evening star have long been associated in literature and poetry and there is no reason to separate them in astronomical study. Even the beginner wishes to answer correctly when some one rings up on the telephone and asks: "What is the evening star near the moon tonight?" To identify a planet is rather a pretty problem, though not quite so simple as some popular writers make out, quoting the old legend, "A planet is known from the stars because it does not twinkle." There is no harm in applying the test. It works well when the planets are already known! More trustworthy guidance is provided by the Old Farmer's Almanac, nor should it detract from the interest and value of the data that they are often given in symbolical form, by quaint old signs that date back to the beginning of human records. Thus, on the second calendar page for February, against the 27th, there are three symbols and, turning to page 3, we find the first means opposition, or 180°, the next stands for the planet Saturn, the third for the sun, and so the three together signify that Saturn is 180° from the sun.

Before fixing upon one planet to identify it, it is well to take into consideration all the five, known as the bright planets. To distinguish between them is essential. It is not enough to know that a particular celestial object is a planet, often it is harder to know which planet. To illustrate with a practical exercise, let us make a careful examination of planetary positions on February 20. Mercury requires little attention, for it is the one of the five that stays constantly so near the sun that only occasionally can it be fairly well seen, and in February of this year there is no favorable opportunity (p. 4. O. F. Almanac). Indeed, unless this planet itself is to be observed, little thought need be given to it at any time. It is never a conspicuous object, challenging the eye, and cannot be mistaken for any of the four really bright planets. The brightest of these, Venus, on the date taken, is, as often happens, far removed from the others. As shown by the almanac (pp. 4, 5, 8), it is a morning star during the first half of the year, slowly but steadily approaching the sun, rising about 2 hours before it February first; and as Mars, Jupiter, and Saturn are up before midnight, there should be no danger of confusing Venus and these three.

If then, the problem is to identify Saturn on February 20, it is necessary to consider it only in connection with Mars and Jupiter, and in the first tentative effort, Mars too may be eliminated as it rises a long time, nearly five hours, after Saturn (p. 5, almanac). The crucial question then is, when and where, on February 20, shall we look in the heavens for Jupiter and Saturn? No explicit answer is found in the almanac, but it does give data that make an intelligent observation possible. It is seen that the times when the planets rise differ by 2 and 1/2 hours, Saturn appearing 1/2 hour after the sun sets and Jupiter 2 hours before (pp. 5, 8, almanac). Since they are 180° from the sun on the 3rd and 27th, their points of rising are probably near together, and placed on the horizon approximately as far north of the east point as the sun sets south of west (p. 9, almanac).

It is then with some very definite data at hand that observing begins on the 20th. After the sun has set and twilight begins to fade, it is known that only two of the bright planets, Jupiter and Saturn, are above the horizon; that the former is well up though not at a high altitude, and the latter low near the horizon line. There is good reason also to expect that when it is dark enough to see them, they will be in the vicinity of the prime vertical, as the planets move south after rising. It is not difficult to be fairly sure of Jupiter on account of its very brightness. It is, on the night considered, the first object to emerge from the twilight, appearing brighter even than Sirius, which is farther south. Saturn, doubtless, will not be visible till twilight ends and not then unless the sky is really clear. An object that appears near the place fixed, decidedly below and north of Jupiter, dull and dim compared with it, that certainly is not α or β Leonis, stars that must be very carefully identified, that object is probably Saturn and a provisional identification is fairly claimed. Not a little more, however, is required before one would care to risk much if mistaken. The writer could tell a fearsome tale about the false identification of this planet. Later, after the constellations have been more thoroughly mastered, and there has been more practice in estimating angles and distances, the final steps must be taken, though it would be an excellent exercise for beginners to devise ways and means of their own for proving beyond peradventure of doubt that the object observed is a planet and that planet Saturn.

In the long warfare waged against ignorance, it is sometimes an advantage to drive a narrow wedge deep into the enemy's territory, but large and permanent conquests are usually won only by an aggressive attack all along the line. And this is the application thereof. Although Lesson II is devoted mainly to new topics connected with moon and planets, it by no means follows that sun and stars may be neglected. Especially is it important to carry forward the series of the sun's diurnal paths. An interval of two weeks between them is not too short, though if, on an average, a path is obtained once in three weeks,

the record is excellent. While the method suggested of making eye-estimates is satisfactory for one or two paths, after that, it is desirable to employ some mechanical appliance for determining altitude and azimuth. As simple a form as any may be obtained by riveting together two wooden rods, 18 inches long and 1/2 inch wide. They should move easily, but not too easily, for after they have been opened to measure an angle, they should remain unchanged in position till the angle between them has been read off from a large protractor.

In the following list of topics for the second lesson, two parts, *a* and *b* are usually given when observations are to be made, in the hope that unfavorable weather or other causes may not cut out both:

Lesson II.

1. Learn the names and learn how to make the symbols of the Greek letters from ι to π, inclusive.

2. Define azimuth, amplitude, celestial equator, declination, right ascension, ecliptic, zodiac; sidereal month, synodic month, lunar phases, limb, terminator; angle of elongation, and conjunction and opposition in terms of elongation. Young's Elements, Arts. 20, 27, 31, 36, 112, 114, 141, 156, 492, 157, 140, 289.

3. Examine both calendar pages of the Old Farmer's Almanac for the current month, reading the second one by substituting for the signs their names and meaning taken from page 3.

4. Determine another path in the series of diurnal paths of the sun, following the method illustrated in Lesson I, or making measures with "jointed-rods" or other mechanical aids.

5. *a.* Observe the crescent moon, as near new as possible, writing notes regarding its color, brightness, limb, terminator, cusps (horns), recording the time of setting, with estimate or measure of amplitude, and giving a sketch of a small section of the horizon with the setting point marked.

b. Determine a diurnal path of the moon, preferably after first quarter, locating four or five positions if possible, including meridian altitude and amplitude at setting. See topic 4.

6. *a.* Locate the moon among the stars, twice in the same lunar month, with an interval of one or several days. See illustrative observation, given on previous page.

b. Instead of two positions for the moon, fix one among the stars.

7. Study and marshal as effectively as possible the data obtained from the common small almanac that are calculated to aid in any way in identifying both Venus and Mars on February 16.

8. Make a provisional identification of Venus or Mars, some time during February, giving an account of the preparation required for the particular date, and the different steps in the observation.

9. Study Map I and Map II of Young's Uranography, planning

alignments for identifying circumpolar and zodiacal constellations, and naming the leading stars, as far as the Greek letters have been learned.

10. *a*. Identify seven constellations found near the pole or in the zodiac, and note the position of five stars in each, comparing map and sky.

b. Identify seven constellations anywhere in the heavens, and note stars as in *a*.

A report of the provisional and final identification of Mars will be especially appreciated.

Route 9, Box 77, Lawrence, Kansas.

CELESTIAL PHOTOGRAPHY FOR AMATEURS BY AN AMATEUR.

By DEAN B. McLAUGHLIN.

As a rule, I believe that amateur astronomers have, on the whole, remained aloof from the field of celestial photography. This is probably not because they have no inclination to apply photography to their work, but because they do not realize the full power of their instruments. They are apt to think that their telescopes can accomplish nothing in this line. It is the purpose of this article, therefore, to show just what results can be obtained with the smallest and crudest of apparatus. The reader should bear in mind that the largest instrument I have ever used for photography is a 2¼ inch telescope of 34 inches focal length.

In February, 1915, I experimented with a No. 2 Brownie camera and found that with the instantaneous exposure of its shutter, it was possible to obtain very good pictures of the moon. Although only a millimeter in diameter, these images show all the naked-eye details of the moon. I then constructed the lunar camera with which the accompanying photographs were obtained (Figs. 2 to 5).

This is a light-proof wooden box about five inches square and six inches deep (Fig. 1). The front of the box is double. In the first thickness of wood there is a hole large enough to admit the eye-piece end of the telescope. The next thickness is pierced with a hole as large as the rear lens of the eye-piece. In back of this hole is the shutter, which consists of a slip of cardboard with a hole in it. The exposure is made by allowing this hole to pass by the eye-piece. This shutter is operated by a rubber band, which is perhaps the simplest and most

PLATE IV

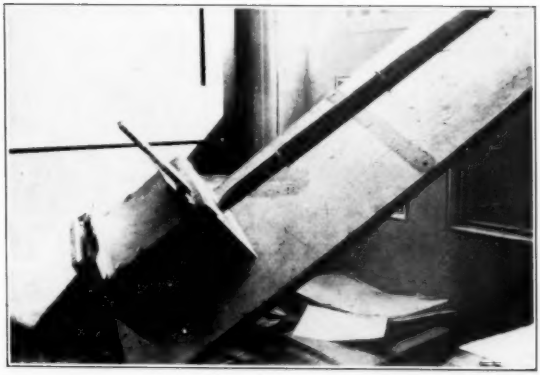


Fig. 1. Small telescope for lunar and solar photography.

Fig. 2. Solar Eclipse at New York,
June 8, 1918, $11^h\ 06^m$ G.M.T.

Fig. 3. Oct. 22, 1915.

Fig. 4. Oct. 25, 1915.

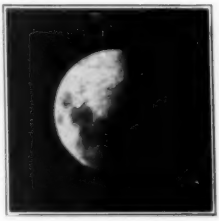


Fig. 5. Sept. 3, 1919.

THREE PHOTOGRAPHS OF THE MOON.

efficient shutter spring for such a camera. The back is open and carries a ground glass screen. There is an opening to accomodate a four by five plate-holder. The principle employed in this apparatus is that of *projection*, i. e., the image of the moon is projected on the plate, just as the solar image is projected on a screen for the study of sunspots (See Fig. 1).

For some time I used a small telescope of the type popularly known as a "spy-glass". A lunar image about 22 mm. in diameter was obtained with an exposure of half a second. The negatives thus taken were rather thin and did not show objects on the terminator. Later, using the 2¼ inch telescope, denser negatives were obtained somewhat smaller than the first. These showed many details on the terminator, but this topic will be discussed later.

The telescope and camera are securely mounted on a board. It may be propped against any handy object. Of course, with this arrangement, it is impossible to follow the moon. The apparent motion per second, due to the rotation of the Earth is:

$$m'' = 15'' \cos \delta$$

where δ is the declination of the moon. Since the moon is never as much as 29° from the Equator, its minimum motion is more than 13″ per second. Therefore, with the telescope at rest, an exposure of more than half a second would materially injure the smaller details. The farther the plate is from the eye-piece, the larger will be the image obtained; but the larger the image, the thinner will be the negative. From experience I have found that it is best to make the diameter of the image *one third of the aperture of the telescope*. Thus, with a 2¼ inch instrument, I make the image of the moon about ¾ inch in diameter.

When photographing the sun, I use my "spy-glass" and obtain a much larger image. My greatest difficulty has been in obtaining a short enough exposure. When taking a solar photo, the shutter is allowed to drop as fast as the rubber band can move it. When photographing the moon, it is lowered slowly with the hand.

The prints can never do justice to the original negatives. The nearest to perfect prints are a few lantern slides which a friend made from my negatives. To give an idea of the delicate details obtained with this seemingly insignificant apparatus, I will summarize a catalogue which I made of the craters found on the plates by careful microscopic examination. On first examination of 32 plates, a total of 51 craters, whose names I knew, were found. A second examination resulted in listing 11 more. These craters ranged from Clavius down to craters twenty miles in diameter. Many unnamed craters only ten miles in diameter were found. Some appeared only once, but many were found on four or five plates. In addition to this, a photograph of Venus in the crescent phase was obtained. The crescent was dis-

tinct under the microscope. The image was only a third of a millimeter in diameter.

Since my telescopes are not mounted equatorially and have no driving clock, it would appear that the photography of the stars is impossible with my equipment. However, I was able to convert my tripod into an equatorial mounting by re-adjusting the legs. As for the driving clock, the hand is a fair substitute.

The stellar camera (Fig. 6) consists of a cardboard box, at the front of which is a common *reading-glass*. The shutter is a sheet of cardboard before the lens and is raised and lowered by means of two strings. The camera is strapped to the tube of the telescope. It is evident that if a star be followed so as to remain in the field of the telescope, that star will occupy a nearly fixed position on the sensitive film. To keep it as accurately in one place as is possible with such an instrument, a pair of cross-threads is placed between the lenses of a negative eye-piece. The star image is thrown out of focus so as to obtain a small disc on which the cross-threads stand out clearly. A Premo film pack is used because small enough plates could not be obtained.

The operation with this instrument is as follows. First, the film pack is placed in position, the focus having been found. Then a bright star in the region to be photographed is selected and its image brought to the intersection of the cross-threads. Then, *and not until then*, the shutter is opened and the star is followed so as to remain at the intersection of the threads. If by any chance it escapes from the field, the shutter is closed at once. The following of the star in this manner is nervous work. I have never been able to continue it for more than ten minutes. A total exposure of half an hour or more should be given for most photographs.

Of course there are numerous disadvantages. First, if the telescope is not accurately mounted as an equatorial, the star may leave a trail, although this will never be very long. Secondly, the reading-glass lens is not corrected for spherical aberration. If a camera with a wide lens, such as the Graflex, is available, it should be used by all means. If a driving clock is used, the photographer should, nevertheless, remain at the eye-piece to correct any irregularities of motion. Figures 7 and 8 were obtained with the apparatus described above. The negative of Fig. 7 shows more than 20 stars and that of Fig 8 shows over 40.

Lastly, we come to the use of the hand camera. The two series of photographs shown in Figs. 9 and 10 were obtained by leaving the camera in one position until it became necessary to start a new row. At intervals of five minutes or so, photographs were taken. Fig 9 was over-exposed. Fig. 10 was taken with the lens stopped down to

PLATE V

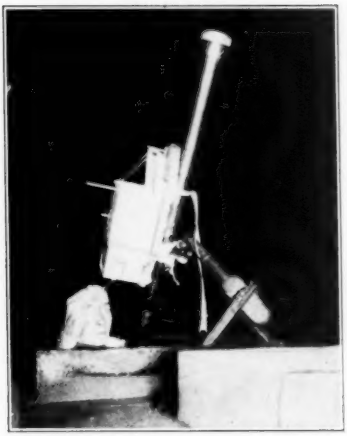


Fig. 6. Stellar Camera mounted on telescope tube.

Fig. 7. Altair and Vicinity Aug. 27, 1919. Exposure 25 minutes.

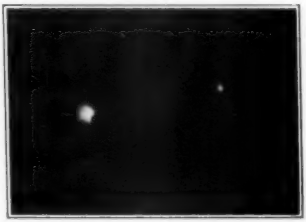


Fig. 8. α and γ Cygni Aug. 28, 1919. Exposure 40 minutes.

Fig. 9. Serial Photograph of Lunar Eclipse, Jan. 7-8, 1917.

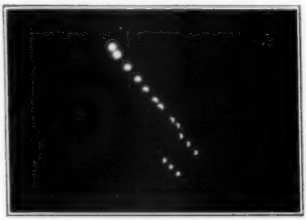


Fig. 10. Serial Photograph of Solar Eclipse June 8, 1918, at New York

little more than a pinhole and giving an exposure of $\frac{1}{50}$ second. Both were taken with a No. 2 Folding Brownie.

Concerning the results that may be obtained with various instruments, I will say that I do not believe it beyond the power of a three inch telescope to obtain recognizable photographs of Saturn and his rings, provided the telescope has a good driving clock and is equatorially mounted. Other good objects for such an instrument would be Jupiter and his satellites and Venus, not only as a crescent, but in all her phases. Two or three minutes exposure should be given for Jupiter's moons.

There are a few points which it will be well for a beginner in celestial photography to bear in mind.

1. Don't sacrifice density in the negative, for the sake of obtaining a large picture.

2. Don't try to photograph the moon through a thin film of cloud. The cloud absorbs a large proportion of the blue end of the spectrum.

3. The same applies to any heavenly body when near the horizon.

4. Remember that the intensity of light varies inversely as the area over which it is spread.

5. Don't expose more than half a second unless a driving clock is used.

I have found the Stanley dry plate, manufactured by the Eastman Kodak Company, perfectly satisfactory for all my work.

513 Hoover Ave., Ann Arbor, Mich. Nov. 10, 1919.

SIRIUS AT SEA.

As though from lonely ocean grave,
Above the landless eastern wave,
The night sun Sirius ascends
Ere eightbells ring and dogwatch ends.

Amid the cloudless winter sky
Its splendor charms the sailor's eye
When far from native land and home
He gazes on yon starlit dome.

A gorgeous and resplendent gem
Is Canis Major's diadem!
Beneath Orion's gleaming light
And Rigel scintillating bright.

Supernal, silent and sublime,
Undimmed, unchanged by course of time,
Canicula at sea ascends
Ere eightbells ring and dogwatch ends.

CHARLES NEVERS HOLMES.

41 Arlington St., Newton, Mass.

THE FRENCH REPUBLICAN CALENDAR AND SOME OTHERS.

By ROSCOE LAMONT.

At the time of the French Revolution a new calendar was adopted in France that was considered to be more scientific than the Gregorian calendar which it replaced. A new era was established, September 22, 1792, being designated as the first day of the year one. "No longer can we count the years when kings oppressed us as a time in which we have lived." The new calendar, however, was not adopted until 1793. The week was discarded and its place taken by the decade. It was planned at first to have a day of ten hours, to divide the hour into ten equal parts, each of these parts into ten others, and so on, but this proposal was not carried out. The reasons for establishing the new system and for beginning it on the date mentioned above were stated as follows when the plan was presented in September, 1793:

"The arts and history, for which time is a necessary element, demand a new measure of duration, freed from all the errors which credulity and superstitious routine have transmitted from ages of ignorance to our own. It is this new measure which the National Convention presents today to the French people. It must bear at once the imprint of the enlightenment of the nation and the character of our revolution, by its exactness, its simplicity, and by its freedom from all opinion which is not acknowledged by reason and philosophy. Time opens a new book to history, and in its march, simple and majestic, like equality, it must engrave with a new and pure burin the annals of regenerated France. September 21, 1792, the representatives of the people, united in the National Convention, opened its sessions and pronounced the abolition of royalty. This day was the last of the monarchy. It is to be the last of the common era. September 22nd this decree was proclaimed in Paris, this day was decreed the first of the Republic, and this same day at 9 hours, 18 minutes, 30 seconds in the morning, the sun arrived at the true autumnal equinox, entering into the sign of Libra. Thus the equality of days and nights was marked in the heavens at the very moment when civil and moral equality was proclaimed by the representatives of the French people as the sacred foundation of its new government. Thus the sun illuminated at once both poles, and successively the entire globe, the same day that the torch of liberty, which is one day to enlighten all mankind, shone for the first time on the French nation in all its purity."

The new calendar was largely the work of Romme, a native of Riom in central France. He was a man of great ability, a radical of the most extreme type, and in 1792, at the age of forty-two, was elected a member of the National Convention. Three years later he was arrested, brought before a military commission, and committed suicide by stabbing himself in front of the judges who had condemned him to the guillotine.

Astronomers were not in favor of adopting a new calendar. Lalande said that the one in use, which most of the nations followed, ought to be retained, that the reform of Pope Gregory was a piece of

foolishness, and that there was no need or reason for making any further changes. The advice of astronomers, however, was not heeded and a new calendar was made, the Egyptian one being taken as its model. The year was divided into twelve months, each containing thirty days, and as this gave but 360, to complete the year, five additional days were placed after the twelfth month in common years and six in leap year. The month was divided into three decades, the last day of the decade being the day of rest. To the months Romme gave the names regeneration, reunion, fraternity, liberty, Bastille, Republic, etc.; to the days of the decade such names as cockade, pike, plow, compass, cannon. Romme derived the names of the months from the history of the revolution, and from his report, an extract of which is given above, the part relating to the names and order of the months is quoted as follows:

Order of the months	
	The French people, fatigued by fourteen centuries of oppression, and alarmed by the frightful
7th from Mar. 21 to April 19	progress of corruption, of which a court, for a long time criminal, gave and provoked the example, felt the need of.....Regeneration
8th from April 20 to May 19	The resources of the court were exhausted, it convoked the French, but their.....Reunion
9th from May 20 to June 18	was their salvation. They appointed, representatives whose courage angered the tyrant. They are threatened, but reassembling at the.....Tennis Court
	and under the safeguard of the people, they pronounced the oath to draw the people from tyranny
10th from June 19 to July 18	or to perish. This oath resounded throughout France. Everywhere men armed, everywhere they wished to be free. The.....Bastille
11th from July 19 to Aug. 17	fell under the blows of.....People
	sovereign and enraged. The malevolent multiplied, treason broke out, the court formed plots,
12th from Aug. 18 to Sept. 16	perjured representatives sacrificed the interests of the nation to sordid views, but the.....Mountain
(the 5 complementary days follow)	
	always faithful, became the Olympus of France.
1st from Sept. 22 to Oct. 21	Surrounded by the nation and in its name, the National Convention proclaimed the rights of the people, the constitution and the.....Republic
2nd from Oct. 22 to Nov. 20	.....Unity
3rd from Nov. 21 to Dec. 20	.....Fraternity

4th from Dec. 21 to Jan. 19	are the force of the French, and.....Liberty
5th from Jan. 20 to Feb. 18	by a sovereign act of national.....Justice
6th from Feb. 19 to Mar. 20	which caused the head of the tyrant to fall, is forever united with holy.....Equality

The first five articles of the act establishing the Republican calendar were as follows:

1. The French Era is counted from the foundation of the Republic on September 22, 1792, of the common era, the day on which the sun arrived at the true autumnal equinox, entering into the sign of Libra at 9 hours, 18 minutes, 30 seconds in the morning by the Paris Observatory.

2. The common era is abolished for civil use.

3. The beginning of each year is fixed at the midnight beginning the day on which the true autumnal equinox falls according to the Paris Observatory.

4. The first year of the French Republic began at midnight September 22, 1792, and ended at midnight separating the 21st from the 22nd of September, 1793.

5. The decree which fixed the beginning of the second year on the first of January, 1793, is repealed. All the acts dated in the second year of the Republic from January 1st to September 22, 1793, exclusive, are to be regarded as belonging to the first year of the Republic.

After these five articles had been adopted, the following discussion took place as reported in the Moniteur, the official paper published at the time:

Bentabolle: The National Convention, in establishing the French Era, has done all that it ought to do. I think that it ought to stop on this article. It is useless and even dangerous to change the subdivisions of time and their denomination. When Mahomet, conqueror and legislator, gave another era to the people subject to his power, his purpose was to separate them from the rest of men, and to inspire in them a superstitious respect for the worship which he prescribed for them. Our purpose is the opposite of that of this impostor. We wish to unite all people by fraternity, and, therefore, instead of breaking our communications with them, we ought, if possible, to increase them. I ask that the rest of the bill be postponed.

Lebon: I am opposed to postponement. If fanaticism could by this means strengthen its empire, why should we not use it to establish liberty?

The reporter presented Article 6 thus conceived:

The year is divided into twelve equal months of thirty days each, after which follow five complementary days to complete the 365 days of the year. These five days do not belong to any month.

Article 6 is adopted.

The reporter presented the moral names to be given to the months, decades and days.

Duhem: Citizens, The French Revolution has not yet touched the end marked by philosophy, and already it has presented memorable epochs which legislators would be pleased to consecrate. But who can tell them that what they might insert would be the greatest that will be produced? Let us not do like the Pope of Rome, who fills his calendar with saints and when new ones come has no place to put them. From this point of view I propose to hold to the ordial denomination which is the most simple. The result follows which you

seek. Our calendar, which would only be that of the French nation, will become that of all nations. They will never depart from the numerical order which is that of nature. You will avoid the rocks on which all legislators who have preceded you have fallen.

Romme: It is necessary that each day recall to the citizens the revolution which has made them free, and that our patriotic sentiments be revived by reading this eloquent nomenclature.

The assembly closed the discussion and adopted the moral names.

Romme: The first day is that of husband and wife.

Albitte: All days are days of husband and wife. (on applaudit)

Lebon: This reflection ought to make you feel the absurdity of some of these names and persuade you to abandon them all. Besides, the difficulty in loading the memory with so many names will cause the old ones to be preserved and you will miss your aim. I ask that the assembly revoke its decree and hold to the ordinal denomination.

The assembly revoked its first decree and determined for the ordinal denomination of the months, decades and days.

Fabre d'Eglantine: I propose to give to each day the name of the plants which nature produces at that time and of the useful animals, which would be a means of public instruction. I ask that a committee be charged with examining this idea.

This proposal was not adopted, but on October 18 a committee was appointed to propose names for the months and days, and Fabre d'Eglantine, one of the members, was charged with the duty of preparing the report and inventing the names. The date of the adoption of the calendar was October 5, 1793, but it was considered as beginning on September 22, 1792. When the names given to the months and days were accepted, the act was again passed on November 24, 1793, with some changes, the act of November 24th containing sixteen articles and that of October 5th seventeen.

After the moral names proposed by Romme had been rejected, and before the names invented by Fabre d'Eglantine had been adopted, the months and the days were known only by their number. It was necessary to say, the twentieth day of the first month of the second year of the Republic. As Michelet says: "Time had the invariable face of eternity."

The calendar as adopted had one defect which was considered so serious that steps were taken later to remedy it. The year was to begin on the day of the true autumnal equinox at the preceding midnight. According to this rule the leap years would not always occur at regular intervals of four years, sometimes once in five years, and they would come about half the time in the even years and the other half in the odd years. Further, if the time of the equinox was very close to midnight there might be a difficulty in determining on which one of two days the new year ought to begin. A bill was therefore prepared which contained the following provisions:

Art. 1. The fourth year of the Era of the Republic will be the first leap year. It will receive a sixth complementary day and will end the first Franciade.

Art. 2. The leap years will succeed each other every four years and will mark the end of each Franciade.

Art. 3. Of four consecutive centurial years there are excepted from the

preceding article the first, second and third, that is, the years 100, 200 and 300, which will be common years. The fourth centurial year will be a leap year.

Art. 4. This method will be followed for every period of four centuries until the fortieth which will end with a common year, the year 4000.

This bill amending the calendar and providing a long life for it was prepared in 1795, during the third year of the new era. The astronomer Delambre had taken the lead in making this correction, which was simply the adoption of the Gregorian method of intercalation, with the addition of Article 4, but before the bill was enacted into law, Romme, who had charge of the matter in the Convention, died suddenly, and the bill was never passed. The third, seventh and eleventh years were the ones actually reckoned as the leap years during the time the calendar was in existence.*

But to return to Fabre d'Eglantine, whom we left on the seventh day of the third decade of the first month of the second year of the Republic, assigned to the work, because of his poetical talent, of inventing names to do away with this clumsy nomenclature. The names given to the months made known, by their etymology, the season of the year in which each month was placed. He says:

"We have thought of giving to each month of the year a characteristic name which indicates the temperature and the kind of productions of the earth peculiar to it, and which shows at once the season of the year in which it is found among the four of which the year is composed. This last effect is produced by four endings given to each of three consecutive months, and producing four sounds, each one of which indicates to the ear the season to which it is applied. We have even thought to profit by the imitative harmony of the language in the composition and the prosody of these words and in the mechanism of their endings, so that the names of the months which compose the autumn have a grave sound and a mean measure; those of winter a heavy sound and a long measure; those of spring a gay sound and a short measure, and those of summer a sonorous sound and a broad measure."

The autumn months were:	Vendémiaire	(vintage)
	Brumaire	(fog)
	Frimaire	(sleet)
The winter months:	Nivôse	(snow)
	Pluviôse	(rain)
	Ventôse	(wind)
The spring months:	Germinal	(seed)
	Floréal	(blossom)
	Prairial	(pasture)
The summer months:	Messidor	(harvest)
	Thermidor	(heat)
	Fructidor	(fruit)

The days of the decade were named Primidi, Duodi, Tridi, Quartidi, Quintidi, Sextidi, Septidi, Octidi, Nonidi, Décadi. These names were

*The writer in the Cambridge Modern History says that the extra day was added at the end of the years preceding leap years. He is going to have the years divisible by 4 leap years even though they contain but 365 days. Carlyle, in his French Revolution (1837), says that the new era began September 22, 1792, close to the *vernal* equinox. Carlyle in 1834 applied for a position in the Edinburgh Observatory.

very convenient as they indicated at once the day of the month. Tridi was the 3rd, 13th or 23rd of the month, Sextidi the 6th, 16th or 26th, Nonidi the 9th, 19th or 29th, and since one would almost certainly know whether the month was beginning, near its middle or end, the day of the month would be known from the day of the decade.

The five additional days placed after the twelfth month were called sansculottides, and these days were dedicated to Virtue, Genius, Labor, Opinion and Rewards. The sixth day in leap year was the Day of the Revolution.

The greater part of the report of Fabre d'Eglantine, which fills nearly two pages of the Moniteur, is of little interest, but a few sentences will be quoted in which he gives the reasons for dedicating the days of the year to the productions of the earth, and to the animals and instruments useful to the farmer:

"Since the calendar is something one has often recourse to, we should take advantage of this frequent use to introduce among the people elementary rural notions; to show them the riches of nature; to make them love the fields, and to point out to them with some system the order of the influences of the heavens and of the productions of the earth. The priests had assigned to each day of the year the commemoration of a pretended saint. This catalogue presents neither utility nor method. We have thought that the nation, after having driven away from its calendar this crowd of the canonized, ought to find in place of it all the objects which compose the true national wealth, objects worthy, if not of its worship, at least of its cultivation: the useful productions of the earth, the instruments which are used to cultivate it, and the domestic animals, our faithful servants in these labors, animals much more valuable no doubt in the eyes of reason than the beatified skeletons drawn from the catacombs of Rome. Consequently we have arranged in order, in the column of each month, the names of the true treasures of rural economy. The grains, the trees, the roots, the flowers, the fruits and the plants, are arranged in the calendar so that the place and the date which each production occupies are precisely the time and the day when nature presents it to us. At each Quintidi, that is, at each semi-decade, the 5th, 15th and 25th of each month, there is inscribed the name of a domestic animal, with precise relation between the date of this inscription and the real utility of the animal named. Each Decadi is marked with the name of an agricultural implement, the very one the agriculturist uses at the precise time at which it is placed. Thus the husbandman on the day of rest will find consecrated in the calendar the implement he is to take up again the next day; a touching idea, it seems to me, which will show our nurse-fathers that with the Republic has come the time when a farmer is more esteemed than all the kings of the earth put together, and agriculture counted as the first of the arts of civil society. It is easy to see that by this method there will not be a citizen of France who, from his tenderest youth, has not made, insensibly and without perceiving it, an elementary study of rural economy."

The part of the calendar which dedicated the days to horses, plows, potatoes, and the like, was unsparingly ridiculed, and a month is given below, from a Farmer's Almanac of the Year 3, showing the agricultural implements, the animals and vegetables which replaced the saints of the old calendar.

Automne Vendémiaire Premier mois
Le premier répond au 22 septembre (vieux style)

Jours du mois	Noms des jours	Productions naturelles et instruments ruraux
1	Primidi	Raisin
2	Duodi	Safran
3	Tridi	Châtaigne
4	Quartidi	Colchique
5	Quintidi	Cheval
6	Sextidi	Balsamine
7	Septidi	Carotte
8	Octidi	Amarante
9	Nonidi	Panais
10	Décadi	Cuve
11	Primidi	Pomme de terre
12	Duodi	Immortelle
13	Tridi	Potiron
14	Quartidi	Réseda
15	Quintidi	Ane
16	Sextidi	Belle-de-nuit
17	Septidi	Citrouille
18	Octidi	Sarrasin
19	Nonidi	Tournesol
20	Décadi	Pressoir
21	Primidi	Chanvre
22	Duodi	Pêche
23	Tridi	Navet
24	Quartidi	Amaryllis
25	Quintidi	Boeuf
26	Sextidi	Aubergine
27	Septidi	Piment
28	Octidi	Tomate
29	Nonidi	Orge
30	Décadi	Tonneau

In 1802, after the re-establishment of the Catholic Church, Napoleon restored the week, and it was recognized that the calendar could not be permanent. Its adoption by any other nation was not to be thought of, and the longer it was continued the greater would be the confusion. The trees, the fruits, the plants and the domestic animals of Fabre d'Eglantine had been forgotten, and the Church was celebrating its saints' days as before. Lalande, in speaking of the discovery of the first one of the minor planets, said: "The first day of the nineteenth century was marked by the discovery of a new planet. I make use of the calendar of all nations, persuaded that the French Government will soon abandon a calendar which is not understood and cannot be adopted either by our neighbors or by the great majority of the French."

On September 9, 1805, an act was passed re-establishing the Gregorian calendar on January 1, 1806. The report of the commission which recommended this was written by the astronomer Laplace, then a Senator, and is in part as follows:

"The project presented to you in the last session, and on which you are to deliberate, has for its purpose the reestablishing in France of the Gregorian calendar on January 1, 1806. We are not to examine here which of all possible calendars is the most natural and the most simple. We shall only say that it is neither the one which is to be abandoned, nor the one which we propose to resume. The principal defect of the present calendar is in its mode of intercalation. In fixing the beginning of the year at the midnight which, by the Paris Observatory, precedes the true autumnal equinox, it fulfills indeed, in the most rigorous manner, the condition of constantly attaching the beginning of the years to the same season, but they then cease to be periods of regular time easy to divide into days, which must produce confusion in chronology already too much embarrassed by the multitude of eras. Astronomers, to whom this defect is very sensible, have many times requested its reform. Before the first leap year was introduced into the new calendar, they proposed to the Committee of Public Instruction of the National Convention the adoption of a regular intercalation, and their request was favorably received. Romme, the principal author of the new calendar, drew up, in concert with several savants, a bill by which a regular mode of intercalation was substituted for the one previously established, but implicated a few days after in a terrible event, he perished, and his plan was abandoned. It would be necessary, however, to return to it if the present calendar were retained, which being thereby changed in one of its most essential elements, would present the irregularity of the first leap year placed in the third year. The suppression of the decades caused it to experience a more considerable change. But the most serious inconvenience of the new calendar is the embarrassment which it produces in our foreign relations, by isolating us in this respect in the midst of Europe, which would always continue, for we cannot hope that this calendar would ever be generally accepted. Its epoch relates only to our history. The instant when its year begins is placed in a disadvantageous manner, as it divides between two years the same operations and the same labors. Two centuries were required and all the influences of religion to cause the Gregorian calendar to be generally adopted. It is in this universality, so desirable to obtain, and which it is important to preserve when it is once acquired, that its greatest advantage consists. This calendar is now used by almost all the nations of Europe and America, and was for a long time used by France. It has no doubt many considerable defects. The length of its months is unequal and arbitrary, the beginning of the year does not correspond to that of any of the seasons, but it fulfills very well the principal object of a calendar, by being easily decomposed into days, and by preserving the beginning of the mean year at nearly the same distance from the equinox. Its mode of intercalation is convenient and simple. It is reduced to the intercalation of one day every four years, but suppressing it at the end of each century for three consecutive centuries, re-establishing it at the fourth, and if, following this analogy, the bissextile day is suppressed every 4000 years, it will be founded on the true length of the year. From these considerations your commission unanimously proposes the adoption of the decree presented by the Government."

Michelet says that when the Republican Calendar was adopted it was well received for the people were hungry and thirsty for truth. But the calendar-truth was as bad as the calendar-strife two centuries before, and on the advice of astronomers this new measure of duration was abandoned 12 years, 2 months and 26 days after the date of its adoption.

This calendar was revived in Paris in 1871 when the city was in the hands of the revolutionists, some of the Acts of the Commune being dated 18 Floréal, 25 Floréal, 1 Prairial, year 79.

In 1849 Auguste Comte published a "Positivist Calendar for any year whatsoever; or concrete view of man's preparation, destined

chiefly for the final transition of the Occidental Republic formed, since the time of Charlemagne, by the free connection of the five advanced populations, French, Italian, Spanish, British and German." Comte's object in forming this calendar was to provide a more perfect measurement of time, and one in harmony with the new Religion of Humanity he was establishing. The year was divided into 13 months, each containing 4 weeks or 28 days, making in all 52 weeks and 364 days. The additional day needed to complete the common year was placed at the end and was dedicated to good women, and the extra day in leap year was consecrated to all the dead. These two days were not included in any week or month, and therefore every year would begin on the same day of the week. The old names of the days were retained, though Comte at first substituted others, as Maridi (marriage), Patridi (paternity), Fratridi (fraternity), but he afterwards said the old names ought to be carefully preserved, as they recalled the whole of human initiation and represented the heavenly bodies connected with our planet.

The months were named Moses, representing theocratic civilization; Homer, ancient poetry; Aristotle, ancient philosophy; Archimedes, ancient science; Caesar, military civilization; Saint Paul, Catholicism; Charlemagne, feudal civilization; Dante, modern epic poetry; Gutenberg, modern industry; Shakespeare, modern drama; Descartes, modern philosophy; Frederick Second, modern statesmanship, Bichat, modern science. Each day of the year was dedicated to some person distinguished for his service to humanity, and the one to whom the last day of the week was dedicated was called the Hebdomadal Chief, some of whom were Confucius, Hipparchus, Plato, Galileo, Newton, Mozart. The second, third and fourth days of the week of which Cromwell was chief, in the month Frederick Second (King of Prussia), were dedicated to Franklin, Washington and Jefferson.

This calendar has never been used except by the followers of Auguste Comte, magazines being published in which dates are given by this calendar as well as by the Gregorian, but disregarding the saints of humanity assigned to the days (merely provisional with the exception of the chiefs of the weeks who were to be permanent), it is about the best calendar that could be made.

A number of other calendars have been proposed, but a perfect one cannot be devised, since the year does not consist of an exact number of days, and the whole number of days cannot be divided into an exact number of weeks. One of those proposed divides the year into quarters, each containing three months, the first month having thirty-one days and the other two thirty days each, making ninety-one days, or thirteen weeks, in each quarter, and for the twelve months 364 days or fifty-two weeks. A day would then be added to complete the common year, and two days added in leap year, these days not to be included in any week or month. With this arrangement the year would

always begin on the same day of the week, but the months in any quarter would begin on different days.

But if a new calendar were to be made (of which there is much talk and no need), one similar to that constructed by Aguste Comte would be the simplest and most convenient of any, the year consisting of thirteen months, each month having twenty-eight days except the last, which in common years would be given twenty-nine and in leap year thirty days, the last two being considered as additional days and having names of their own. With these two days forming a part of the last month, they would be registered in the year the same as the other days. The months would all begin on the same day of the week, and dates in the several months having the same number would have the same day name. For example, if the fourth day of January was on Thursday the fourth day of every month would come on Thursday, and a calendar made for one year would be good for every year. The thirteenth month might be named Concordia, and the last day of a common year, which would not form a part of the week, be called Thanksgiving Day, and the additional day every fourth year known as Liberty Day. Thus the year would end in Concord, with Thanksgiving, and with a festival every fourth year dedicated to Liberty.

Washington, D. C.

THE DECIMAL SYSTEM FOR TIME AND ARC FOR USE IN NAVIGATION.

By CHARLES E. MANIERRE.

Whether the day could have been divided more advantageously into a different number of hours, or the circle into a different number of degrees, is not a part of the subject to be considered. The only question is whether it is not worth while for scientific work and particularly in navigation and for the Nautical Almanac, to subdivide hours by decimals of hours, and degrees into decimals of degrees.

It is conceded that for ordinary affairs of life the present division of the hour is most convenient. All men, even those concerned with scientific matters, tend strongly to think and transact business in half and quarters, and not in tenths. Even the second is so closely identified with common affairs that it probably could not be changed with advantage.

Whenever much computation is involved, even in every day affairs, the advantage of the decimal system stands out. No doubt the change

from Pounds, Shillings and Pence to Dollars and Cents caused temporary friction, which did not entirely die out for a considerable period. Yet no one would go back to the old money division nor would anyone consider that the temporary trouble of the change was not abundantly justified.

The idea of the present proposed change is not new. Both four and five decimal tables of logarithmic trigonometric functions have been published, although they are not readily to be obtained. In 1908, Ginn & Co. brought out a four place table of some forty pages by Dr. Granville.

The change from arc to time, or time to arc under the decimal system would be only a matter of multiplying or dividing by 15, instead of the present somewhat involved process, which is not easily remembered nor quickly worked, and involving a possible source of error.

The difference between adding and subtracting under the present system and under the decimal system is obvious, and the advantage of the decimal system considerable, not only as to the time involved but in permitting the mind to remain on the main problem without being diverted to the detail of what amounts to a sub-problem.

One-tenth of a degree of arc as well as one-tenth of an hour in time has the value of six minutes. One-one-hundredth has the value of .6 minutes, or 36 seconds. One-one-thousandth has the value of 3.6 seconds.

It would hardly ever be necessary to subdivide the hour or degree beyond one-thousandth for purposes of navigation. If it were deemed to be a matter of time to be turned into arc, its value in the present system would be 54 seconds, i. e. less than one minute of arc, less than a mile of longitude on the equator, and considerably less in moderate latitudes.

On the other hand the change would require additional pages in logarithmic tables. For five-place tables reading on the margin to single hundredths of a degree, it would take two pages to each degree, although with 50 lines to the page instead of 60. This would permit better spacing and type. The differences would be reduced to tenths instead of for sixty seconds. The additional pages would increase the thickness of such a book as Bowditch's American Navigator by perhaps a quarter of an inch.

The chronometer face is easily large enough to admit of divisions into hundredths of an hour, which might be lettered at each tenth, with an extra long line midway between each lettering. Thousandths would be indicated by the hand corresponding to the second hand, the circle for which could be divided into ten parts and subdivided, if it seemed advisable, to obtain a closer reading. Forty divisions would indicate time slightly less than a second.

The sextant marking would present no great difficulty and some advantages. It should be understood in the beginning that the ten-second spaces on large sextants and one-minute readings on the verniers of small sextants were not determined because they were exactly the best for use, but from the necessity of dealing in even minutes and seconds. In fact it has been unfortunate that the division had to be into single minutes for sight tube use, thus exactly co-inciding with the extreme limit of definition of the human eye, and it probably will be conceded that the ten-second reading, so far as actual sextant markings and computations from observations are concerned, would have been better at twelve or thirteen seconds, if these spaces had represented round numbers.

Under the decimal system the large sextant would doubtless be divided to two-tenths of a degree (equal to 12 minutes) on the arc, and by expanded vernier, with forty or with fifty subdivisions on the vernier, to either .005 of a degree for each subdivision into forty. (equal to 18 seconds), or .004 of a degree for each subdivision into fifty (equal to 14-2/5 seconds). In the first case the vernier would be lettered 0, .05, .10, and .20 with extra long division lines midway of the figures; in the second case, with fifty subdivisions, the lettering would be 0, .04, .08, .12, .16 and .20, with an extra length of line midway between the lettering.

The forty division vernier would, of course, be more convenient to read and the question would be whether the equivalent of 18 seconds could be deemed sufficiently exact for all purposes. An experiment or two will show that the fifty division vernier is not so difficult to read as a first view of it might suggest. It will never add more than a single full tenth to those read upon the arc, nor will the unnumbered divisions of the vernier increase the second place of decimals by more than three units.

Some sextant arcs of the present time are divided into quarter degrees and could be, of course, read as .25, the only change with them being to a vernier of fifty subdivisions, which would also read to .005 of a degree. In like manner the small sextant arc now reading to 30 minutes could be deemed to be .5 of a degree as the smallest division of the arc and the vernier only would need to be changed from 30 subdivisions to 25 subdivisions, each of which would have a value of .02 of a degree (equal to 1-1/5 minutes). In this case, each fifth mark would be lettered: 0, .1, .2, .3, .4, and .5. As already stated such a division would seem to have a distinct advantage in permitting a little leeway to the eye, and not requiring of it the extreme limit of its capacity when used with a sight tube.

A necessary incident of the proposed change would be a table giving the value for each one-hundredth part of a degree or hour in minutes and seconds, and a corresponding table giving the decimal

value of each minute. The first table would require a supplement showing the value in seconds of each one-thousandth up to ten and each ten-thousandth part up to ten, and for the second table a supplement showing the decimal value of each fourth second. All of this information would be contained on two pages. If these tables read directly to each fourth second for the second table and to thousandths for the first table, they would be more convenient and would not occupy more than ten pages.

The table for every fourth second, on account of its peculiar detail may be of interest, and is as follows:

$1'' = .000277+$ of a degree or hour.

$4'' = .00111$	$40'' = .01111$
$8'' = .00222$	$44'' = .01222$
$12'' = .00333$	$48'' = .01333$
$16'' = .00444$	$52'' = .01444$
$20'' = .00555$	$56'' = .01555$
$24'' = .00666$	$60'' = .01666$
$28'' = .00777$	
$32'' = .00888$	
$36'' = .01$	

Strictly speaking, the last figure when over five ought to be increased by one, in view of the fact that the decimal beyond would be a large one.

There is also a rhythmic repetition in the decimal of minutes, which may be indicated as follows:

$1' = 0^{c}.0166$	$7' = 0^{c}.1166$	$13' = 0^{c}.2166$
$2' = .0333$	$8' = .1333$	$14' = .2333$
$3' = .05$	$9' = .15$	$15' = .25$
$4' = .0666$	$10' = .1666$	$16' = .2666$
$5' = .0833$	$11' = .1833$	$17' = .2833$
$6' = .1$	$12' = .2$	$18' = .3$

and so on, through the full number of minutes up to sixty.

These tables would be, of course, only for incidental use where some item required for computation was found expressed in the old style, or when it was necessary to translate the final result in time, for example, into its minute and second value for non-scientific purposes.

To make the system useful for the navigator, it would be important to issue the Nautical Almanac in decimal form, and to provide a volume containing certain tables from Bowditch in decimal form.

It would be perhaps sufficient if this volume included Tables 14, 15 and 16, all upon a single page,—24 being the parallax and refraction of the moon,—26 and 27, used with Ex-meridians,—41, natural sines, —44, Trig. functions log. —45, haversines,—46, combined corrections for sun and star.

It has already been said that the logarithmic table of Trig. functions would be considerably increased in length. This would be true also of the haversine table, the top of each column in which would indicate

one-one-hundredth of an hour increase over the preceding column and .15 of a degree of arc, so that the approximate increase in the table would be in the proportion of 100 to 60.

The table would still be 60 lines to the page, divided so that each one-hundredth of a degree would be noted on the margin with three intervening logarithmic values, showing a quarter difference and being equivalent to a haversine table divided to 9 seconds of arc instead of to 15 as at present. In hours, every sixth logarithm would be marked on the margin for .001 of an hour, equal to 3.6 seconds, and therefore the logarithms would read without interpolation to .6 of a second of time, instead of to 1 second as at present.

The table would occupy approximately 180 pages as against 106. The time intervals between .001, .002, etc., in the haversine table would read .001, .00116, .00133, .00150, .00166, and .00183. The volume thus proposed would be a little larger than H. O. 200.

It is safe to say that the decimal system being once in operation we will be fortunate if our successors do not regard the old system as an absurd survival which our mental indolence had too long tolerated. If they make the effort to turn time into arc and arc into time by our present system, their astonishment will be doubtless increased that such a clumsy arrangement had not been consigned to the scrap heap long ago.

New York, Aug. 20, 1919.

REPORT ON MARS, NO. 22.

By WILLIAM H. PICKERING.

General Instructions.

This report has been somewhat delayed, not for lack of material, which is abundant, but because of pressure of work on other matters. It is hoped to deal with the many interesting observations made at the last apparition in subsequent papers. In the mean time both astronomers and amateurs, whether members of the Associated Observers of Mars or not, are invited to make their drawings of the planet, and forward them as heretofore, together with the required data, to the writer, not later than July 1. When drawings by different observers are to be compared, and canals and lakes identified upon them, as in this case, it is very desirable that the drawings should be forwarded promptly. Those arriving after the first of August will be given due

attention and consideration, and will be published if possible, but it is hoped that unnecessary delays will not occur.

It is proposed to maintain the Miscellaneous column established in Report No. 21. In it will be published the drawings of those unable to send complete sets, and also drawings by those whose sets we are not able to publish in full. It may be pointed out in this connection that longitude 120° shows less detail than any other in the series. Because it shows but little, observers should not be discouraged from drawing it, nor from sending in their drawings. As pointed out in Report No. 21, it may be well for those fairly familiar with the planet to study this region with extremely low powers, such as 150 to 200, as well as with the higher ones of 400 to 600 customarily employed. By thus bringing out all the contrast obtainable between the large featureless areas exhibited by this region it is possible that some explanation can be found of the diverse results secured by different observers in 1918, and possibly a better agreement may in future be obtained.

Specifications for the six drawings required to make a set, will be found in Reports Nos. 11, 15, and 18. New observers are cautioned that under no circumstances should they take a map of the planet with them to the telescope, to help them find the canals and lakes. That is not the proper way to observe. See Statistics of the Canals, in Report No. 21. They are also cautioned against trying to see too many canals and other details. A good rule is not to enter anything on the drawings that is not surely seen. Omit everything that is merely occasionally glimpsed. We should always compute the time at which the required meridians are central before beginning to observe, so that we may know at what time to begin the drawing (See Report No. 15). This requirement is most essential.

Data of the Apparition.

Opposition occurs this year April 20, but on account of the great eccentricity of the orbit of Mars, the planet will not be nearest the Earth until a week later. Its diameter will then be 16″.1. In 1918 it was only 14″.1. It is suggested that the six drawings should all be made between March 20 and June 1. On these dates the diameter of the planet will be 13″.0 and 13″.8 respectively. As heretofore, however, drawings of earlier, and of later date, if better, may be sent in. The declination will range from 12°.3 to 8°.4 south. The summer solstice of the planet occurs on February 8 of our calendar, and March 20 corresponds to the Martian Date July 9. Similarly June 1 with us corresponds to August 26 with them. Our drawings will therefore be made this year in the height of their summer season. We shall consequently see the maximum number of fine canals in their northern hemisphere, and the number of lakes should also be very large. We can also perhaps watch them as they are beginning to fade and dry up. After March 10 we shall see the planet to better advantage, that is

to say it will be nearer us, than it has been for many years at that season of the Martian year.

Alterations in the Ephemeris.

Observers of Mars throughout the world will notice with gratification, that in the case of the published diameters of the planet, the authorities have now gone back to the value determined by Hartwig, 4″.68 for the semi-diameter, at unit distance, corresponding to a linear diameter of 4215 miles. This is the value used for many years by the British Nautical Almanac, and only changed by them for the last two or three apparitions. It will not be necessary therefore in future for observers to correct the diameters given in the Ephemeris in order to reduce them to this value.

American observers will also be particularly pleased to notice two other changes in their Almanac. In the first place the ephemeris is computed for Greenwich Mean Midnight, instead of Noon, that is to say for 7 p. m. E. S. T. This is much nearer the hour at which the majority of observations are made, and if we adopt the constant 14°.62 for the hourly rotation of Mars throughout the apparition, which for most purposes is very convenient, then all of our interpolations will be more accurate than they would have been if the ephemeris were still computed for Greenwich Noon. Observers working on Mars in 1919 will notice that these two changes are made on the date of January 1, 1920.

The second change in the American Ephemeris consists in the introduction of a second column giving the "Central Meridian for the Intermediate date." As this is the most important, and most used quantity in the whole table, it will be a distinct convenience to have it given for every day of the apparition.

It is occasionally desirable to determine quickly the distance of Mars on any given date. This may readily be done by multiplying the Light Time given in the Ephemeris by 11,250,000, the velocity of light in miles per minute. To obtain the distance in kilometers multiply by 18,000,000.

Discordant Results in 1918.

In comparing the work of the different observers in Report No. 21, one of the most striking differences is found to lie in the size of certain central figures in the regions **E** and **F**. The extreme cases occur in the second and third columns of Plates VI and VII, though in no two cases do the different observers agree very well. Such differences should not be, and it is hoped will not occur at the coming apparition. At first sight it might appear rather difficult to determine which drawings are correct. Although, as compared to eye observations, photographs give very inferior results, yet here is a case where photography may well be called in to settle a disputed point. The best photographs

of the planet hitherto taken have been at the Lowell, at the Mt. Wilson, and at the Yerkes Observatories. The writer is fortunate in possessing examples of the best work done at each of these stations. The longitudes of Aryn and of the Syrtis Major seem to have been favorites with the photographers, but fortunately a very successful series was taken by Mr. E. C. Slipher in Chile, of the surface about Elysium, shown in region **E** with the Amherst 18-inch equatorial. An enlargement of this photograph is shown in Plate VI. The date is July 13, 1907, and the canals bounding Elysium present the well known pentagonal form characteristic of the earlier apparitions of the present century. This form is still shown according to some of the observers, while to others it now appears nearly circular. Its diameter in the photograph, measured west from the center of Charontis to Hyblaeus, as well as we can measure it is 4.0 mm; the diameter of the planet is 18.0 mm, ratio 0.222. In the drawing the ratio ranges from 0.228 in Figure 18, to 0.326 in Figure 19. The ratio in Figure 17, the next to the smallest, is 0.256.

The writer may give here a brief description of his method of getting the proper proportions. The polar cap is first located, and carefully drawn of the correct size. Then any other points on the limb or terminator, especially any nearly opposite to the polar cap, are inserted. We next locate any point near the center, such for instance as the rim of Elysium, and then draw the northern and southern boundaries of the southern maria. After checking these fundamental points and lines carefully, the filling in of the other detail can be done with little error. The size of any circle-shaped area, such as Elysium, is always estimated in terms of the radius or diameter of the disk, and then the breadth of the surrounding area is estimated in terms of the diameter of Elysium, which thus serves as a check. Points are always sought out which form an equilateral or isosceles triangle. Regions along the eastern limb or terminator are preferably drawn first, since detail disappears upon that side. Some observers make a slight allowance in their proportions for the motion of the planet, during the time they expect to require to locate their fundamental points. The writer seldom finds that necessary, since the fundamental points and lines can usually be located quickly, while the final detail can always be put in at one's leisure.

On comparing the drawings and photographs of the lunar canals in my paper on Eratosthenes I (Popular Astronomy 1919, **27**, 579), while the photographs are on a somewhat larger scale, yet after allowing for that fact, we see that the canals are on the whole drawn rather too narrow. The measured and corrected ratio between them is as two to one, but it is likely that the photographs represent the canals as rather too wide, so that the proper correction to the drawings may perhaps be fifty per cent. This fact may have a bearing on the drawing of the canals of Mars as represented by other observers.

PLATE VI

PHOTOGRAPHS OF MARS.

The engravers have failed to bring out much of the detail which is shown in the enlarged negative from which they worked. The reader may see the pentagonal outline of the region Elysium, to which Professor Pickering refers, by holding the printed picture, either too far from the eye or too near the eye to be in good focus, so that the granular structure of the image is lost. Elysium is a white region just below the center of each picture, seen best perhaps in the middle one, where it is bounded on the upper edge by two black spots, on the lower edge by the dark streak just above the polar cap and on the three sides by very faint streaks. The two black spots are the Trivium Charontis and the Lucrinus Lacus. Editors.

THE LIMITATIONS OF THE FILAR MICROMETER.

The filar micrometer is so valuable an instrument for double star work that it seems at first almost heresy to say that it is of little use for planetary measurements of position and survey. Where the threads can actually be set on two near objects, like two stars, and held on them, as can be done with the modern giant refractors, the result is eminently satisfactory. But where a smaller instrument is employed, such as is better adapted to studying planetary detail, and the threads are constantly swinging back and forth through an arc of one or more seconds, as is the case with smaller and inferior mountings, one of two different methods of measurement must be adopted: (*a*) A thread is made to coincide approximately with each of the objects to be measured, and when the threads swing to the ends of their path we must see that the two objects are equally remote from them, or (*b*) the threads must be placed to one side of the two objects, and the distance between the threads made equal to that between the objects themselves. With the latter method for small distances, smaller accidental errors are usually obtained, and there is no necessity of waiting until the threads swing to the end of their course.

But whether attached to large or to small telescopes, either for small disks, or for planetary detail, the micrometer is of little use. The cause of the trouble is the systematic error. In measuring the diameters of small illuminated artificial disks of about 1″ in diameter, with the 15-inch equatorial at Cambridge, it was found that by method (*a*) the result averaged 0″.20 too large, and by method (*b*) 0″.33 too small, and that the poorer the seeing the smaller the result. Consequently if we use method (*a*) with extremely poor seeing, the systematic error becomes very small indeed. The measurement of the location of detail on illuminated disks also gave large systematic errors, and since these errors varied with the seeing, and also with the proximity of the detail to the limb, it became evident that they were very uncertain quantities, and could never be satisfactorily corrected (H. A. **32**, 133). It must be remembered also that even a spider's web appears very coarse as compared to the finer details on Mars, or the Moon, and bears about the same relation to the finer canals as a walking stick does to a wire. Moreover the detail is often very faint, and as a result, when the spider's web is introduced into the field of view, the detail utterly vanishes.

Nevertheless there are two uses to which the filar micrometer may be put in connection with planetary astronomy. One is to the measurement of the diameters of large planetary disks, and the other to the measurement of the polar cap of Mars. It is true that we cannot decide by this means what the real size of the cap may be, with any great accuracy. The systematic correction would have to be determined by drawings, or otherwise, and would vary with the diameter of

the cap. But we can measure the *variations* of size from night to night, or from hour to hour, with the micrometer, with much greater accuracy than we can obtain them by any other method. In the case of drawings the accidental errors are large, but the systematic errors small; with the micrometer the reverse is the case, the accidental errors being small, and the systematic errors large. In the study of Martian storms, we don't care what the real size of the polar cap may be, we want to study its variations only. The real size may be determined by a comparison of a sufficient number of drawings by different observers. Several of the Associated Observers have already sent me measures of their drawings made at the last apparition, and it was hoped to have reduced and compared them before this. It is expected to do so in the near future. In the mean time, besides drawings, it is recommended that micrometric measurements of the cap be secured whenever possible, both in Europe and America.

The Polar Regions.

On March 20, the date selected for beginning the drawings of Mars, the central latitude of the disk is only $+16°.0$, but it increases gradually, so that by June 1, when the last drawing is to be completed, the latitude will have reached $+22°.9$. This is very nearly its maximum possible value, so that since the polar canals appear to develop rather late in the season, we should have a still better view of them this year than we had at the last apparition. The summer solstice occurs at the Martian Date June 27, and in 1918 the border of the polar cap reached its highest latitude, about 85°, some two weeks later. This will occur with us this year on February 22, which would lead us to expect that throughout our observations the polar cap will be increasing in size, and the whole of it will be visible except when later crossed by the terminator. The increase at first slow, later becomes rapid, and we should have an excellent opportunity to study the form and extent of the successive precipitations, and probably to determine whether they were generally associated with clouds or with clear weather.

The melting of the polar caps is always readily observed, because this occurs when they are turned towards the Sun, and consequently towards the Earth at opposition. The formation of the caps on the other hand occurs during their winters, and consequently can never be well seen. Every advantage should therefore be taken of whatever opportunities are presented to us. Moreover, since the successive increments in their size are probably due to snowstorms rather than to frost, the increasing size of the caps is of far more interest than their diminution. Photographic observations made in 1888 and 1890 lead us to associate the increasing size of the caps with clouds, and at that time there were indications that successive increments of cloudiness at the two poles tended to occur simultaneously (H. A. **53**, 155). Should this prove to be generally the case for Mars, it would be of in-

terest to see if a similar rule applied to the Earth. Visual observations this year should yield more conclusive results.

We have assumed so far that the phenomena of the northern polar cap was always the same year after year. This does not however appear to be the case. Thus, while in 1899 and 1901 its diameter at the time of the solstice was 25° and 24°, in 1903 it was but 18°, and in 1918 only 12°, or according to Mr. Phillips 7°. In 1903 the cap remained clear of cloud for at least 120 days after the solstice, when its diameter was steadily and continuously reduced to 8°. In 1918 its minimum size, 10°, was, as we have already seen, reached two weeks after the solstice, and the cap remained clear until at least 157 days later, when its diameter had increased to 25°. In 1905, on the other hand, the cap proper was not seen at all, the polar regions having become completely clouded over at 80 days after the solstice (Mem. B. A. A. 1903, 1905). As already noted, the solstice occurs this year upon February 8. European observations combined with those made in America, by permitting the observation of the duration of the storms to be continued through a considerable interval of time, may yield very interesting information and advance our knowledge of the meteorology of the planet considerably. As indicating what we may expect to record, a brief account may be given of an increase of the polar cap observed in 1918. See also Report No. 20, Snow Storms.

February 12, solar longitude ⊙ 72°.9, M. D. May 45, longitude of central meridian λ 32°, latitude of center of disk $\beta + 21°.6$, diameter 12″.0, diameter of snow cap 17°.4. The brightness of the snow was only 8 on a scale of 10, but its color was white, not yellow.

February 16, λ 303°, the diameter of the cap was reduced to 11°.4, but a light cloud near the terminator in longitude 210° extended 14°.2 south of the cap. A bright area was observed in this location in 1903 and called Olympia by Antoniadi. It was seen at intervals as late as June 11, ⊙ 126°.7, M. D. July 49.

February 17, λ 328°, the diameter of the cap had increased to 13°.8, but the extent of the cloud was reduced to 8°.4. In a second drawing, λ 347°, the cloud had disappeared.

February 18, λ 293°, diameter of the cap 13°.6, but it was now completely surrounded by a fainter bright ring, diameter 23°.2. The brightness of the cap had increased to 9, that of the outer ring was 8.

February 19, λ 279°, the brightness of the cap was now uniform throughout, 9 to 10, and its diameter 21°.0. Its outline however was hazy, as if surrounded by a narrow ring of cloud, or by snow only partly covering the ground. Its size had not appreciably diminished on February 27, 20°.0.

A bright cloud appeared near the southern pole on February 18, was visible on February 19, and on February 27 covered a large portion of the southern hemisphere, thus corroborating the earlier photographic conclusions. A series of micrometric observations by Mr. Phillips in

1918 gave for the diameter of the cap on February 6, 11°.9, for February 18, 22°.9, and for February 27, 10°.2. The divergence between our results for the last date is marked, and difficult to explain (Journ. B. A. A. 1919, **29**, 219). It is clear that a combination of micrometric measures made in Europe and America would have yielded interesting results. It is also certain that a series of position angles for the snow and for the temporary cloud would have been valuable. These are not difficult to obtain if we set the threads parallel to the snow, and between it and the center of the disk, and compare with the trail of the planet when the clock is stopped. The observed angle as compared with the ephemeris would then give the deviation from the Martian Pole.

By means of a careful series of micrometric measurements, we may hope to make the best use possible of this unusually favorable apparition for a study of the Martian storms. A knowledge of these storms will doubtless add to our knowledge of the meteorology of other portions of the planet, where the precipitation cannot be observed through our telescopes. Since the southern polar cap is quite eccentric, its position when small lying some 6° distant from the Pole, in longitude 50°, according to Lowell ("Mars" page 84), it is quite possible that towards the end of our observations, unless heavily clouded, it may make itself visible also, in this longitude. At all events the southern polar clouds, and the changes in their dimensions should be a distinctive feature of this apparition.

Shifting Surface Detail.

With regard to the determination of latitudes and longitudes on Mars, for the latitudes we must depend on large scale drawings some two inches in diameter, and for the longitudes on the time of transit across the central meridian, as fully described in Reports Nos. 13 and 18. In the former, the use of the micrometer is recommended for latitudes, but unless the point observed is near the centre of the disk, it is now believed that better results can be secured by means of careful drawings made as described in the latter, under the subtitle "Shifting of the Canals". In addition to the vertical diameter there mentioned, a horizontal one will be found of considerable assistance. The former is turned parallel to the Planet's Axis, and on it is indicated by a short cross line the position of the point under observation. From two such drawings carefully made, one before and one after the transit, the latitude can be determined far more accurately than from an ordinary drawing of the whole disk.

These methods of measurement are readily applicable after the northern polar cap becomes visible, at the time of the vernal equinox, and while it is diminishing in size, or between solar longitudes ☉ 0° and 120°. The later increases in size, due to precipitation, are believed to occur irregularly in different longitudes, thereby making the cap temporarily eccentric about the pole. Position angles of the cap should

therefore be taken as above described, to determine this eccentricity. The south polar cap, as already mentioned, is always eccentric, and its eccentricity probably varies with the season, so excepting for objects transiting near the centre of the disk, corrections for eccentricity are always necessary after ⊙ 120°. This longitude is reached this year on April 14, but the corrections are not expected to be large before May. It is suggested that it may be possible to use the centre of the planet's disk in place of the snow cap without a serious loss of accuracy. That is, after setting the thread in the eyepiece parallel to the planet's axis by means of the ephemeris, we should note when the centre of the disk and the point under observation are equally distant from the thread. It is probable that the shading on the side of the terminator would affect the determinations of longitude, even allowing for the defect of illumination *q*, when this latter quantity exceeds 0.04 of the diameter of the disk. Determinations of positions should therefore be confined if possible within the interval between March 20 and May 20.

Efforts have been made by the writer to secure latitude and longitude observations by other observers at both of the last apparitions. In 1918 he was partially successful, and a preliminary comparison of their results, corroborating his own, leaves little question in his mind but that some of the points observed have shifted. Thus in 1879 Schiaparelli found the longitude of Aryn to be 356°.1 on the ephemeris now in use. In 1890 Wislicenus made it 3°.7. In 1892 the writer found it 1°.4. In 1894 Lowell made it 0°.3. In 1918 Phillips found it 357.°0 and Douglass 355°.0. It seems unlikely that anyone should make an error much greater than 1°, yet the difference between Wislicenus and Douglass is 8°.7, corresponding to a time interval of 36 minutes. The construction curve, based on these and other observations, which best accords with the facts is a sinusoid, having a period of 16 years, an amplitude of 6°, and a minimum longitude of 356° occurring in 1916. That is to say Aryn is farthest to the east in the Martian April and May. This curve is merely provisional, but longitudes not far from 359° should be found this year, unless the shift in longitude is very irregular, or the accepted period of rotation of the planet, as suggested by Lowell, is quite erroneous. In the latter case longitudes of about 356° should be found. It is consequently most desirable that these observations should be repeated this year. A somewhat similar sinusoid applies to Syrtis Major, save that it was farthest east in 1914, or in Martian March and April.

The first measurements of Edom were made by the writer in 1892, who secured eight determinations of its longitude and nine of its latitude. It was measured by Lowell in 1894, by G. Fournier in 1912, and again by the writer in 1914. These are all the measurements known. The results of these four series are given below. The contrast between the accordance of the results and the variability of the

measures of Aryn is striking. The writer's investigations hitherto lead him to believe, unless future observations indicate a variation, that the longitude of this point is as well, or better known, than that of any other on the planet. The mean of the first two results as compared with that of the last two indicates that after an interval of twenty years, there is no evidence of error in the accepted rate of rotation of the planet.

TABLE I.

LONGITUDE OF EDOM.

Year.	Observer.	Long.	Dev.
1892	Pickering	352°.9	−0°.1
1894	Lowell	353.1	+0.1
1912	G. Fournier	352.0	−1.0
1914	Pickering	354.2	+1.2
Mean		353°.0	±0°.6

It is hoped that observations of both longitudes and latitudes will be secured by a number of observers this year. The positions of as many of the following points as possible should be determined. Following each point is given its longitude and latitude according to our standard map (Report No. 15), and then a brief description of its characteristics.

1. Aryn; 0°, −4°. This point is very a poor one for purposes of observation, since it is subject to great changes in appearance. It has however been selected as the origin of longitudes on Mars, and has been observed many times by different observers. It is included in this list for these reasons. It usually appears as a dark rhomboid, projecting from the mare towards the north. This is the case on dates preceding the summer Solstice. On dates following it, a light covered wedge with its apex towards to south, Aryn proper, bisects the dark area. The appearance of the point observed should be carefully described.

2. Edom Promontory; 356°, −8°. Very sharply defined, with strong contrast, and undoubtedly the best point for longitude determinations upon the planet. It presents the same appearance, and is fairly conspicuous, at nearly all seasons of the year. For latitude we should select the boundary where it extends farthest to the south, near longitude 350°.

3. Ismenius Lacus; 335°, +39°. A fairly conspicuous, and therefore rather large lake, but a good point to measure.

4. Portus Sigeus; 334°, −7°. Sometimes well seen, and perhaps as stable as any point on the list.

5. Syrtis Major; 283°, +20°. The northern point should be measured. The most conspicuous marking on Mars, and probably subject to considerable changes of position. In 1916 its longitude according to Barnard was 258°.0, according to the writer 284°.2. In

1918 Phillips made it 289°.4 (Journ. B. A. A. 1918, **29**, 52). This year it is expected to approach 293°, a higher longitude than has ever hitherto been recorded for it. The canal Nilosyrtis swings back and forth with it.

6. Triton Lacus; 262°, + 12°. In case the lake itself is not visible, the canal Thoth leading due south from it should be observed for longitude, the location being selected as near the lake as possible.

7. Boundary between Hephaestus and Elysium; 235°, + 20°. A sharply defined line.

8. Boundary between Elysium and Charontis; 200°, + 17°. A sharply defined line, and with its predecessor well adapted to determine the longitudinal width of Elysium.

9. Laestrigon Sinus; 200°, — 25°. This bay has of late been more marked than as shown on the map. While very far to the south, it is an important point.

10. Titanum Sinus; 170°, — 20°. A marked and very important point. Rather difficult on account of its southern latitude. It should be measured early in the season. Has been suspected of a considerable shift.

11. Castorius; 155°, + 52°. It may appear as a lake or as the southern end of a bay. On account of its latitude it will be difficult to measure after this apparition.

12. Phoenicis Lacus; 106°, — 16°. A very important point, and probably very conspicuous in a few years, but of late it has been rarely recorded.

13. Messeis Lacus; 80°, — 5°. Best identified as the spot where the canal Kedron branches off to the north. A small local map showing this lake and canal is given in Report No. 17.

14. Lunae Lacus; 65°, + 19°. A large hazy region, but occasionally small and defined.

15. Junction of Ophir with Aurorae Sinus; 63°, — 7°. Interesting because subject to marked change.

16. Juventae Fons; 61°, 0°. Small and difficult, but suspected of marked change in longitude.

17. Niliacus; 30°, + 28°. The southern point at the junction with Hydaspes. Conspicuous and changeable.

18. Oxia Lacus; 20°, + 13°. In case the lake is not visible the northern part of Magaritifer should be measured. Suspected of considerable shift.

19. Thymiamata Promontory; 20°, — 3°. Like Edom its southern limit should be measured for latitude, in case the end of the promontory is not well defined. There is evidence of marked change in latitude.

20. Siloe Lacus; 5°, + 34°. Sometimes well defined.

Of these 20 points Aryn, Edom, Syrtis, Ophir, Oxia, and Thymiamata are perhaps the most important, and Ismenius, Hephaestus,

Charontis, Titanum, Phoenicis, and Niliacus are next. Some are interesting as being especially stable, and others as especially liable to shift. Measurements of the same point made on preferably three different nights are very desirable.

Colors Exhibited by the Planet.

It was found in 1918 that the deserts of the planet were red, matching No. 12 of the Color Scale until ⊙ 62°, that they were yellow matching No. 11 at ⊙ 80°, and again red later on. This is equivalent to saying that on the Martian Date of May 21 the deserts were red. By June 6 they had turned yellow, and were again red later on in August. This would appear to indicate that during the summer season the deserts are so only in name. The beginning and end of the crop (not necessarily by any means artificial) has now been well located, but its color in late May and early June has not at this writing been determined satisfactorily. Its duration is about thirty weeks. Observations made in 1915 (Report No. 11) indicate that the crop is a semi-annual one. Color measurements are now being made at regular intervals, and a description of them will appear in a subsequent report. A possible, but less probable explanation of the yellow color observed at this season, is that it is due to low lying fog or mist covering the deserts. The source of light, and colored medium employed in these measurements are described in Report No. 18. For the Color Scale see Popular Astronomy 1917, **25**, 419, and for the Color Wedge, Report No. 20. The latter was made with colored crayons, which are easier to control than water colors.

The southern maria which were experiencing their early winter weather were generally gray when well seen in 1918, with sometimes a slight greenish tint, like that of our remote pine clad hills. Towards the end of the present apparition they are expected to assume a fresher and more brilliant hue. The northern maria on the other hand which were in the midst of their June appeared brownish, and were markedly different in color from the southern ones. This fact, not so noticeable at recent apparitions, clearly implies vegetation. Some doubt has been expressed by one observer as to whether the bright blue color sometimes noted in the Syrtis might not be due to chromatic aberration of the objective. If this were so, it should always be seen, which is by no means the case. The color appears only shortly after the beginning of a flood. In the case of Acidalium, it only shows when the melting of the polar cap is at its height. Mr. Phillips states that colors are better seen with his 12 and 18-inch reflectors than with his 8-inch refractor. This is natural, since the reflectors give more light. He notes especially the very "beautiful greenish blue" color of the Syrtis on March 23, 1918; noticed also as unusual by several other observers at about this time. Mr. Ellison, using an 18-inch mirror, speaks of the "full sky blue" color of the Syrtis on March 21. The

writer recorded it with his 11-inch refractor in a color sketch on March 24. The tint as represented about matches No. 5 of the Color Scale, but is more heavily shaded. On March 28 he describes it as "very blue" and as rather more so than as shown in the color sketch.

Miscellaneous Observations.

We are now approaching the season when small clouds may be seen surrounding the polar cap. Lowell describes a number observed shortly after the passage of the summer Solstice (Annals Lowell Observatory **3**, 191). The eastern or preceding portion of Elysium frequently bears a cloud. Well defined clouds forming or disappearing near the limb or terminator should be carefully sketched at intervals of a few minutes. Clouds projecting beyond the terminator have been seen at this season. Canals surrounding the polar cap darken towards noon with the melting snow, and fade in the afternoon as they evaporate, or freeze with the coming of night. Equatorial Canals on the other hand fade towards noon as they evaporate, and probably darken again later. Nodus Gordii near longitude 120° is especially liable to rapid changes in darkness and location. It should be drawn at short intervals when conspicuous. In Report No. 20, under "Hourly Changes in Brightness," is given a detailed account of the variations detected in the region on both sides of Thoth. Two tropical frosts were recorded at the last apparition, when Mars was nearly at its greatest distance from the Sun. If detected this year, they should be observed, and their outlines drawn with care at frequent intervals. Notes on the color of the broader canals as seen with large apertures may be of value. A search for hourly changes in the finer canals should be made. This should include their curvature, duration, possible shifting of position, longitudinal development, and the formation or disappearance of any lakes in connection with them. Long continued observations on the same night if change is suspected, are desirable. The quality of the seeing should be noted frequently during the observation. In case any changes are noted. These changes would have a bearing on the interpretation of the canals, whether as marshes or as vegetation, and would therefore be of considerable importance.

Table II gives the data of those drawings made in Jamaica after March 16, 1918. Report No. 20 gives the data for the previous drawings of the apparition. Following the table is given a list of the canals and lakes identified on each drawing. The main object of these lists, which have been continued since our first Report, published in 1914, is to record under uniform and favorable conditions, as the Martian seasons progress, the dates of appearance, disappearance, and continued visibility of every canal and lake that it has been possible to identify on the surface of the planet.

TABLE II.

DATA OF THE DRAWINGS.

No.	1918	⊙	M. D.	Long.	Lat.	Sun	Diam.	Seeing.
54	Mar. 21	89.0	June 25	334°	+21.7	+24.0	14".1	7
55	" 22	89.5	" 26	335	21.8	"	"	9
56	" "	"	" "	358	"	"	"	8
57	Apr. 3	94.8	" 38	301	22.0	23.9	13.6	7, 6
58	" 4	95.2	" "	219	"	"	13.5	10
59	" "	"	" "	243	"	"	"	9
60	" "	"	" "	271	"	"	"	8
61	" 5	95.7	" 39	217	"	23.8	13.4	7
62	" 8	97.1	" 42	181	22.1	"	13.2	9
63	" 20	102.5	" 54	94	22.5	23.4	12.1	7
64	" "	"	" "	115	"	"	"	7
65	Apr. 21	103.0	June 55	57	22.4	23.3	12.1	9
66	" 28	106.1	July 6	343	22.8	23.0	11.6	10
67	" "	"	" "	1	"	"	"	11
68	" "	"	" "	27	"	"	"	11
69	May 2	107.9	" 10	301	23.0	22.7	11.1	7, 6
70	" 5	109.3	" 13	273	23.1	22.6	10.9	9, 8
71	" 9	111.1	" 16	248	23.3	22.3	10.6	9
72	" 14	113.5	" 21	214	23.6	21.9	10.1	10
73	" 28	120.0	" 35	97	24.3	20.6	9.0	8
74	" 30	121.0	" 37	59	24.4	20.4	8.9	8
75	June 1	122.0	" 39	34	24.5	20.2	8.8	7
76	" 2	122.3	" 40	31	"	20.0	"	8
77	" 3	122.9	" 41	4	"	"	8.7	8, 9
78	" 4	123.4	" 42	2	"	19.9	"	10
79	" "	"	" "	17	"	"	"	10
80	" 9	125.8	" 47	337	24.7	19.2	8.3	10
81	" 10	126.3	" 48	323	24.8	19.1	"	9
82	" 11	126.7	" 49	302	"	19.0	"	8
83	" 24	133.1	Aug. 5	177	25.0	17.3	7.5	6
84	" 25	133.6	" 6	148	"	17.1	7.4	10
85	" 28	135.0	" 9	121	"	16.7	"	7
86	July 4	138.0	" 15	64	24.9	15.8	7.2	7
87	" 5	138.5	" 16	56	"	15.6	7.1	8
88	" 9	140.6	" 20	26	24.7	15.0	7.0	7
89	" 10	141.1	" 21	2	"	19.8	6.9	7
90	" 16	144.1	" 27	301	24.5	13.8	6.8	7
91	" 18	145.1	" 29	302	24.3	13.4	6.7	7
92	" 20	146.1	" 31	277	24.2	13.1	"	6
93	" 22	147.2	" 33	248	24.0	12.7	6.6	7
94	Aug. 1	152.4	" 42	149	23.2	10.9	6.3	7
95	" 8	156.0	" 49	81	22.4	9.5	6.1	9
96	" 11	157.7	" 52	53	22.0	8.9	6.0	6
97	" 13	158.7	" 54	32	21.6	8.5	"	7
98	" 14	159.2	" 55	21	"	8.3	5.6	6
99	" 16	160.3	Sept. 1	357	21.3	7.9	"	8
100	" 22	163.6	" 7	303	20.3	6.6	5.8	8
101	" 28	166.8	" 13	238	19.3	5.3	5.7	6, 7

CANALS AND LAKES IDENTIFIED ON THE DRAWINGS.

Mar. 21, **BC** Pandora, Gehon, Oxus, Indus Deuteronilus, Protonilus, Callirrhoe, Pierius, Nilosyrtis, Asclepius, Pyramus, Iaxartes, and Caloe, Ismenius.

Mar. 22, **FA** Pandora, Typhonius, Asopus, Nilosyrtis, Astusapes, Protonilus, Deuteronilus, Gehon, Oxus, Indus, Pierius, Callirrhoe,

Iaxartes, and Sirbonis, Ismenius, Arethusa, Oxia.

Mar. 22, **A** Pandora, Gehon, Oxus, Protonilus, Deuteronilus, Pierius, Callirrhoe, Anonymous (c), and Ismenius, Arethusa, Oxia.

Apr. 3, **F** Thoth, Casius, Nilosyrtis, Astusapes, Astaboras, Protonilus, Pierius, Cadmus, and Caloe, Ismenius.

Apr. 4, **DE** Cyclops, Hephaestus, Nepenthes, Triton, Thoth, Casius, Nilosyrtis, Anian, Eunostos, Hyblaeus, Chaos, Boreas, Rhyndacus, Styx ,Cerberus, Erebus, Pyriphlegethon.

Apr. 4, **E** Cerberus, Styx, Chaos, Hyblaeus, Eunostos, Cyclops, Hephaestus, Anian, Nepenthes, Thoth, Casius, Nilosyrtis.

Apr. 4, **EF** Cerberus, Styx, Chaos, Hyblaeus, Eunostos, Cyclops, Anian, Triton, Nepenthes, Thoth, Casius, Nilosyrtis, Astusapes, Protonilus, Pierius, Argeus.

Apr. 5, **DE** Erigone, Phlegethon, Propontis, Hades, Cephissus, Boreas, Styx, Cerberus, Eunostos, Hyblaeus, Chaos, Thoth, Casius, and Charontis, Propontis.

Apr. 8, **D** Marne(P), Titan, Avernus, Laestrigon, Axon(L), Elison(J), Tantalus, Pallene(J), Hebrus, Hades, Pyriphlegethon, Boreas, Styx, Cerberus, Eunostos, Hyblaeus, Chaos, Cephissus, Aesacus, Adonis, and Biblis, Castorius, Propontis, Arsenius.

Apr. 20, **BC** Nectar, Ophir, Daemon, Fortuna, Araxes, Iris, Uranius, Nilokeras, Gigas, Issedon, Tantalus, Tanais, Acheron, and Solis, Tithonius.

Apr. 20, **C** Araxes, Gigas, Ceraunius, Tanais, Acheron.

Apr. 21, **B** Oxus, Indus, Deuteronilus, Callirrhoe, Jamuna, Nectar, Ophir, Daemon(L), Kedron(P), Eumenides, Iris, Nilus, Phlegethon, Chryssorrhoas, Nilokeras, Tanais, and Oxia, Solis, Ascraeus, Hyperboreas.

Apr. 28, **FA** Thoth, Nilosyrtis, Protonilus, Astaboras, Phison, Asopus, Pierius, Arnon, Euphrates, Typhonius, Orontes, Gehon, Deuteronilus, Callirrhoe, and Sirbonis, Hipponitis(J), Caloe, Ismenius, Arethusa.

Apr. 28, **A** Nilosyrtis, Asopus, Orontes, Euphrates, Siticus, Gehon, Indus, Anonymous(a), Astaboras, Phison, Protonilus, Deuteronilus, Pierius, Callirrhoe, Iaxartes, Tanais, and Caloe, Ismenius, Oxia.

Apr. 28, **AB** Protonilus, Deuteronilus, Gehon, Indus, Callirrhoe, Iaxartes, Tanais, and Ismenius, Oxia, Niliacus.

May 2, **F** Thoth, Casius, Pyramus, Nilosyrtis, Astaboras, Astusapes, Protonilus, Deuteronilus, Pierius, Callirrhoe, and Ismenius.

May 5, **EF** Cyclops, Cerberus, Styx, Chaos, Hyblaeus, Eunostos, Hephaestus, Thoth, Casius, Nepenthes, Nilosyrtis, Astusapes, Astaboras, Protonilus, Pierius.

May 9, **E** Cyclops, Cerberus, Styx, Chaos, Hyblaeus, Eunostos, Aesacus, Anian, Hephaestus, Nepenthes, Thoth, Casius, Nilosyrtis.

May 14, **DE** Cerberus, Styx, Chaos, Hyblaeus, Eunostos, Aesacus, Choaspes, Gyndes, Heliconius, Alcyonius, Thoth, Nepenthes.

May 28, **BC** Indus, Jamuna, Nilokeras, Ophir, Fortuna, Iris, Issedon,

Uranius, and Niliacus, Lunae.

June 2, **AB** Siticus, Deuteronilus, Aron, Callirrhoe, Nilokeras.

June 3, **A** Typhonius, Orontes, Protonilus, Deuteronilus, Pierius, Callirrhoe, Gehon, Oxus, and Caloe, Ismenius.

June 4, **AB** Protonilus, Deuteronilus, Callirrhoe, Gehon, and Ismenius.

June 9, **FA** Nilosyrtis, Asopus, Orontes, Astaboras, Protonilus, Deuteronilus, Gehon, Arnon, Pierius, Callirrhoe, and Hippontis, Ismenius, Arethusa.

June 10, **FA** Nasamon, Nilosyrtis, Aspus, Astaboras, Phison, Protonilus, Deuteronilus, Arnon, Pierius, Callirrhoe, and Ismenius, Arethusa.

June 11, **F** Nepenthes, Thoth, Casius, Nilosyrtis, Astusapes, Protonilus, Deuteronilus.

July 4, **B** Nilokeras.

July 5, **B** Nilokeras, Ganges.

July 9, **AB** Indus, Jamuna.

July 10, **A** Protonilus, Deuteronilus, Pierius, Callirrhoe.

July 16, **F** Casius, Nilosyrtis.

July 22, **E** Cerberus, Styx, Casius.

Aug. 14, **AB** Deuteronilus, and Ismenius.

Aug. 16, **A** Protonilus, Deuteronilus, Gehon.

Aug. 22, **F** Nilosyrtis.

Mandeville, Jamaica, B. W. I., January 1, 1920.

YERKES OBSERVATORY 1919.

By EDWIN B. FROST.

Personnel. Mr. Edison Pettit had received his discharge from the Army at the end of December 1918 and continued his duty here as assistant for solar physics through the year. Until June 30 he also assisted in securing the plates for stellar parallaxes with the 40-inch telescope.

Mrs. Hannah Steele Pettit continued her work as assistant for stellar parallax until June 30. She took her examination for the Doctor's degree at the observatory on July 12 and received the degree at the University at the end of the summer quarter.

Mr. Van Biesbroeck left the observatory, with his family, on May 31 for a trip to Belgium. He attended the meetings of the International Astronomical Union at Brussels. He returned with his family and mother and sister on Aug. 23.

Professor Paul Biefeld of Denison University worked as volunteer

research assistant from June 18 to August 29, giving his time chiefly in assisting with the spectroheliograph and doing some photography with the 2-foot reflector.

Mr. O. J. Lee returned on July 1 from an absence of two years as director of the Chicago School of Navigation of the U. S. Shipping Board and resumed his work in the department of parallax.

Professor C. C. Crump of Ohio-Wesleyan University worked as volunteer research assistant from July 1 to Sept. 1, devoting his time to work on certain spectrographic binaries which he had observed here previously. He also relieved Mr. Barrett of observing with the spectrograph for a considerable part of the time.

Professor F. P. Leavenworth of the University of Minnesota was at the observatory from July 8 to July 28 and from August 24 to Sept. 7. He used the micrometers of the 40-inch and 12-inch telescopes for observations of double stars on a number of nights during this period.

Miss Alice H. Farnsworth returned from her studies at the University of Chicago and continued her work with Professor Parkhurst from June 15.

Miss Harriet McW. Parsons, holding a traveling fellowship from Vassar, began a new period of work at the observatory on June 19, using the 2-foot reflector and measuring plates taken with it under the direction of Professor Parkhurst.

Miss Helen N. Davis, instructor in the department of physics at Vassar, formerly computer at Mt. Wilson, worked at the observatory from June 24 to Sept. 15 as computer in spectroscopy, measuring many spectrograms in arrears.

Miss Frances E. Allen, who had just graduated from Vassar, worked through July and August as computer in the department of stellar spectroscopy.

Dr. John Paraskevopoulos, assistant at the National Observatory at Athens, arrived at the Yerkes Observatory on July 30, to be volunteer research assistant. He first gave his time to the spectroheliograph and to the solar spectroscope of the 12-inch telescope, and since September has worked chiefly in the department of stellar spectroscopy.

Miss Evelyn W. Wickham left on August 29, after three years of successful work with the stellar spectrograph and in measuring spectrograms, to take a position in the research department of the American Telegraph and Telephone Company, New York City.

Miss Dorothy W. Block began in the department of stellar spectroscopy on Sept. 8.

Mr. Frederick C. Leonard had his examination for the degree of M. S. at the observatory on July 26, and received the degree at the University at the summer convocation.

Instrumental. The large sheave for turning the 90-foot dome, which had broken toward the end of December 1918, was replaced on Jan. 17, 1919. For twenty-two days it had not been possible to turn the large

dome. However, the opening was nearly in the meridian and accordingly a considerable number of plates for stellar parallax were obtained during the period, but it was not possible to make observations with the spectroheliograph or with the spectrograph.

The driving of the Bruce photographic telescope had always given trouble from a periodic error, although numerous attempts had been made to allay the difficulty. Mr. Burrell, engineer of the Warner & Swasey Company, spent two days in the spring in examining and testing the instrument for this error and, upon the request of Messrs. Warner & Swasey, the instrument was dismounted on May 19 and sent to them. After much careful work had been done at the shop on the worm gear and worm, Mr. Barnard went to Cleveland on July 25 and tested the driving of the telescope at the works for about a week. The telescope arrived in Williams Bay September and was set up on the 21st. The driving of the clock is now satisfactory in every way, thanks to the interest of the Warner & Swasey Company, and the pains taken by them to have this difficulty corrected.

Atmospheric conditions. The best measure of the atmospheric conditions at this station is given by a statement of the hours of observation with the 40-inch telescope. These records have been kept in a nearly uniform manner for seventeen years, so that the conditions for any year may be tolerably well represented by the comparison with the normal. The record only concerns itself with hours of observing at night. When the sky may be clear, but the seeing is too unsteady for useful observations, those hours are not included but are counted out as though it were cloudy.

HOURS OF OBSERVATION WITH THE 40-INCH TELESCOPE AT NIGHT.

1919 Month	Number of Hours	Gain or Loss*
January	174	+ 40½
February	134½	+ 2½
March	127	— 4
April	77	— 47
May	134½	+ 14½
June	126	— 2
July	162	+ 10
August	147½	— 8½
September	147	— 11
October	138	— 37
November	144½	— 2½
December	109	— 33
Total	1621	Loss 77½

* From 15-year normal.

The reduced number of hours of observation in the autumn is correlated with the large amount of rainfall, which in September amounted to 8.24 inches and in October to 5.10 inches. The total rainfall for the

year was 40.4 inches, which is 9.7 inches greater than the normal for 15 years.

Increase of Astronomical Negatives. During 1919 in the department of solar physics, the number of the plates taken with the Rumford spectroheliograph advanced from 7035 to 8173, giving a total of 1138 plates for the year. Seven direct photographs, Nos. 602-608, were made with the 40-inch telescope.

In the department of stellar parallax, plates of fields for parallax and for proper motion in the π series increased from No. 4253 to No. 4888, of which 575 were successful.

Professor Barnard's series F of 8 x 10 plates taken with the 40-inch telescope for clusters and nebulæ advanced from No. 257 to No. 287. With the Bruce photographic telescope, Mr. Barnard's series of Milky Way photographs was increased from No. 1314 to No. 1390. For each number there were at least two exposures, with the 10-inch and the 6¼ inch, and often a third. His series of comets, with the same instrument, advanced from No. 574 to No. 588, the exposures all being in duplicate and some in triplicate.

Mr. Parkhurst's series O for photometric purposes, with the 40-inch telescope, advanced from No. 340 to No. 365. For most of these the object glass was covered with the large parallel-bar grating. The series R, with the 2-foot reflector, increased from No. 3883 to No. 4064: these were chiefly fields of Kapteyn areas and for photometric purposes, and Hagen fields for proper motions around variable stars. The UV series, for photometric purposes, covering plates taken with the Zeiss doublet of ultra-violet glass, progressed from No. 1808 to No. 1851. The OP series, which includes spectra taken with the 15° objective-prism placed over the U.-V. doublet or over the 6-inch reflector of 60 inches focus, advanced from No. 660 to No. 683.

The plates of the sky patrol increased by 100 numbers, from No. 333 to No. 433. Many of them were duplicate exposures, one of the cameras being covered with a 30° objective-prism.

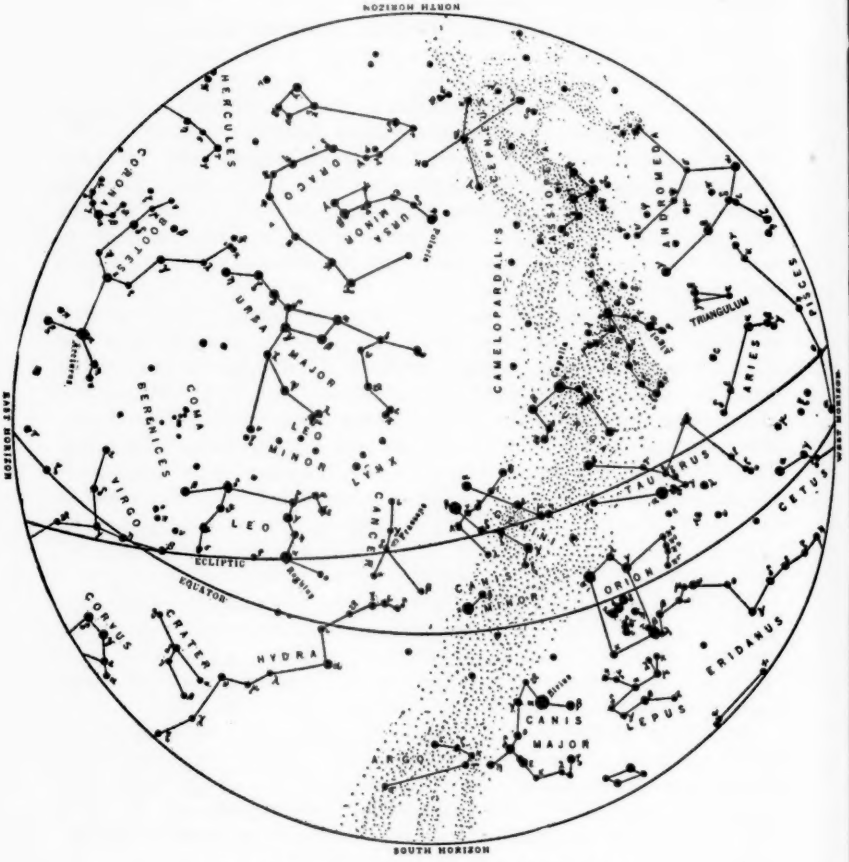
The activity in the machine shop was much limited inasmuch as no regular instrument maker could be employed during the year.

During the summer months over 8000 visitors were received on the public Saturday afternoons, from 1:30 to 4:30. For the benefit of such visitors, in groups of about 200, the operation of the large telescope, dome and floor is demonstrated by some member of the staff, who also gives at intervals of 30 or 45 minutes a description of some part of the work in progress at the observatory.

January 20, 1920.

PLANET NOTES FOR MARCH, 1920.

The *sun* will move northeastward during this month and will cross the equator on Saturday, March 20. This is the date of the vernal equinox and is refer-



THE CONSTELLATIONS AT 9:00 P. M. MARCH 1.

red to as the beginning of spring. The date of the vernal equinox seems to be a day earlier than usual. This is due to the fact of the 29th of February of this year. The sun will pass from the constellation Aquarius into the constellation Pisces through a region in which there are no bright stars.

The phases of the *moon* for this month are as follows:

Full Moon	March	4	at 3:00	P. M.	C.S.T.
Last Quarter		12	" 12:00	M.	"
New Moon		20	" 5:00	A. M.	"
First Quarter		27	" 1:00	A. M.	"

Mercury will reach a position of greatest elongation east on March 3. At this time it will also be a few degrees north of the sun. It will set about one hour and twenty minutes after the sun, and may therefore be seen near the western horizon just after sunset for a few days before and a few days after this date. After this date it will move rapidly toward the sun and be in a position of inferior conjunction on March 19. It will, therefore, be invisible during the rest of the month.

Venus will continue its motion following the sun eastward. Its motion will be a trifle more rapid than that of the sun and it will, therefore, be getting nearer to the sun from day to day. It will be south of the sun and not well situated for observation during this month.

Mars will cross the meridian on the average about three hours after midnight during this month. It will be moving slowly eastward until the middle of the month when it will change and move westward. It will be in the constellation Libra about 20 degrees east of Spica.

Jupiter will be the most conspicuous planet in the evening this month. It will cross the meridian about 9 o'clock in the evening. Its apparent motion in the sky will be westward. It will be in the constellation Cancer, forming at the middle of the month nearly an isosceles triangle with the stars Procyon and Regulus.

Saturn will be a few hours east and a few degrees south of Jupiter. Its motion also will be retrograde during this month. It will be well situated for observation.

Uranus will just be emerging from the sun and will not yet be in a position for observation.

Neptune for a few days at the middle of the month will be within one degree of the planet Jupiter. It will be in practically the same right ascension and less than a degree south. Its proximity to this conspicuous planet may make it easier to find. This planet is visible only in the telescope.

Occultations Visible in the United States, March, 1920.

[NOTE:—Geographical positions are indicated by giving for each point, first the latitude, then the longitude, the two being separated by a hyphen. A line drawn on a map through the two or three points thus indicated will mark approximately the limit of the region of visibility for the U. S.

The time given is the approximate Greenwich time of the middle of the occultation, as seen from the central longitude of that part of the U. S. where it is visible.]

Mar. 1, 16^h. 84 B. Cancri, Mag. 6.4. Throughout the U. S.
Mar. 1, 21^h. A^1 Cancri, Mag. 5.5. Southwest of 42°-125°, 35°-112°, 27°-96°.
Mar. 1, 23^h. A^2 Cancri, Mag. 5.7. West of 48°-84°, 38°-87°, 26°-94°.
Mar. 2, 15^h. ω Leonis, Mag. 5.5. Throughout the U. S. except south of 35°-125°, 33°-105°, 29°-90°.

Mar. 4, 15h. p^5 Leonis, Mag. 5.3. Throughout the U. S. except northeast of 46°-77°, 42°-69°.

Mar. 5, 0h.5. 388 B. Leonis, Mag. 6.3. South of 49°-126, 43°-111°, 41°-89°, and west of 41°-89°, 26°-90°.

Mar. 5, 22h. 78 B. Virginis, Mag. 6.5. Southwest of 40°-125°, 30°-110°.

Mar. 6, 16h.5. ψ Virginis, Mag. 5.0. Northeast of 49°-118°, 42°-96°, 35°-76°.

Mar. 7, 0h.5. 49 Virginis, Mag. 5.2. West of 50°-88°, 25°-100°. (Farther east, occurs after sunrise.)

Mar. 10, 1h. 41 Libræ, Mag. 5.3. South of 46°-125, 44°-115°, 45°-105°, and west of 45°-105°, 30°-105°. (Farther east, occurs after sunrise.)

Mar. 10, 19h. 58 G. Scorpii, Mag. 6.2. East of 28°-110°, 38°-107°, 47°-98°, and south of 47°-98°, 42°-86°, 36°-72°.

Mar. 12, 1h.5. ξ Ophiuchi, Mag. 4.4. Throughout the U. S. west of long. 105°. (Farther east, occurs after sunrise.)

Mar. 14, 1h. 171 B. Sagittarii, Mag. 6.1. Throughout the U. S. west of long. 107°. (Farther east, occurs after sunrise.)

Mar. 14, 1h. 173 B. Sagittarii, Mag. 6.4. Throughout the U. S. west of long. 107°. (Farther east, occurs after sunrise.)

Mar. 24, 18h. 234 B. Tauri, Mag. 6.0. North of 42°-127°, 38°-115°, 33°-101°, and west of 33°-101°, 40°-91°, 49°-79°.

Mar. 24, 19h. ϵ Tauri, Mag. 3.6. Northwest of 30°-123°, 40°-110°, 50°-100°.

Mar. 25, 15h. 351 B. Tauri, Mag. 6.2. South of 45°-125°, 40°-100°, 32°-77°.

Mar. 25, 16h. 353 B. Tauri, Mag. 6.5. Throughout the U. S.

Mar. 26, 12h. 71 Orionis, Mag. 5.1. East of long. 95° and north of 33°-95°, 30°-80°. (Farther west, occurs before sunset.)

Mar. 27, 21h.5. 68 Geminorum, Mag. 5.2. Northeast of 50°-125°, 45°-110°, and northwest of 45°-110°, 50°-101°.

Mar. 28, 12h. 30 B. Cancri, Mag. 6.1. Throughout the U. S. east of long. 90°. (Farther west, occurs before sunset.)

Mar. 29, 13h. κ Cancri, Mag. 5.1. Throughout the U. S. east of long. 100°. (Farther west, occurs before sunset.)

Mar. 30, 16h.5. 14 Sextantis, Mag. 6.3. Throughout the U. S.

Mar. 30, 21h. 19 Sextantis, Mag. 5.9. Northeast of 50°-120°, 40°-99°, 35°-76°.

Mar. 31, 21h. p^3 Leonis, Mag. 6.1. Northeast of 50°-117°, 40°-97°, 35°-75°.

ARTHUR SNOW,
Ass't., Nautical Almanac Office, U. S. Naval Observatory.

VARIABLE STARS.

Maxima in 1920 of Variable Stars of Long Period.—In the Harvard College Observatory Circular 220 Mr. Leon Campbell gives a table of predicted maxima in 1920 of the variable stars of long period for which fairly regular periods have been determined. He says that these maxima can be predicted with a fair degree of certainty now, because of the continually increasing value of the observations which are contributed to Harvard Observatory by outside as well as local observers. Observations have been received during the past year from forty-nine observers in the United States, sixteen in Europe, three in Africa, two in South America, one in Australia and one in Hawaii.

Minima of Variable Stars of Short Period.

[Calculated by members of the Class in General Astronomy in Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5h; Central Standard 6h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1920 March
	h m	° ′		d h	d h d h d h d h d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8	20 8
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	8 5; 15 21; 23 13; 31 5
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	7 10; 14 20; 22 7; 29 17
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	3 23; 11 11; 18 23; 26 11
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	1 11; 7 14; 19 20; 25 22
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	8 6; 13 10; 20 13; 27 17
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	5 19; 12 16; 19 12; 26 9
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	1 1; 8 5; 22 13; 29 17
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	4 21; 13 15; 22 10; 31 5
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	4 16; 12 15; 20 13; 28 12
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6	6 18
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	2 20; 8 14; 20 1; 25 19
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	4 6; 11 1; 24 15; 31 11
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	8 7; 16 4; 24 2; 31 0
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	8 21; 17 4; 25 12
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	3 3; 10 24; 18 21; 26 19
RW Persei	13.3	+42 04	8.8—11.0	13 04.8	9 22 23 3
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	8 0; 17 11; 26 21
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	10 4; 22 13
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	7 2; 13 17; 20 9; 27 1
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	1 17; 9 21; 18 2; 26 6
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	3 17; 9 18; 21 19; 27 19
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	9 2; 17 17; 26 10
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	2 6; 12 16; 23 1
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	4 23; 13 0; 21 0; 29 0
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	2 0; 7 18; 19 5; 24 23
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	3 19; 9 10; 20 15; 26 5
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	7 4; 15 9; 23 14; 31 18
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	8 11; 16 2; 23 17; 31 8
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	5 10; 17 15; 29 20
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	6 3; 13 7; 20 11; 27 15
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	5 14; 12 10; 19 6; 26 1
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	2 13; 11 21; 21 4; 30 11
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	4 14; 11 4; 24 10; 31 1
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	1 5; 9 15; 18 1; 26 10
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	6 19; 13 5; 19 16; 26 2
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	4 3; 11 10; 18 16; 25 23
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	1 18; 9 21; 18 0; 26 3
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	4 9; 13 20; 23 8
RX Hydrae	9 00.8	− 7 52	9.1—10.5	2 6.8	2 10; 9 6; 22 23; 29 19
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	6 16; 12 14; 24 11; 30 9
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	7 2; 13 19; 20 13; 27 7
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	6 15; 14 1; 21 11; 28 21
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	2 0; 8 14; 21 19; 28 10
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	7 10; 16 5; 25 0
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	3 17; 11 0; 18 8; 25 16
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	2 5; 9 0; 22 14; 29 9
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	8 12; 16 0; 23 12; 31 0
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.1	5 1; 14 15; 24 6
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	2 11; 9 22; 17 8; 24 19
133926 Hydrae	13 39.0	−26 23	8.6—12.7	2 21.5	5 1; 10 20; 22 10; 28 5
δ Librae	14 55.6	− 8 07	4.8— 6.2	2 07.9	7 12; 14 12; 21 11; 28 11

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1920 March
	h m	° ′		d h	d h d h d h d h d h
U Coronae	15 14.1	+32 01	7.6— 8.7	3 10.9	4 21; 11 19; 18 17; 25 15
TW Draconis	32.4	+64 14	7.3— 8.9	2 19.3	8 4; 16 14; 25 0
SS Librae	15 43.4	−15 14	9.3—11.5	0 18.4	2 15; 10 7; 17 23; 25 15
SW Ophiuchi	16 11.1	— 6 44	9.2—10.0	2 10.7	6 5; 13 3; 20 21; 28 5
SX Ophiuchi	12.6	— 6 25	10.5—11.2	2 01.5	5 18; 14 0; 22 6; 30 12
R Arae	31.1	−56 48	6.8— 7.9	4 10.2	2 16; 13 12; 22 9; 31 5
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	3 4; 14 6; 23 22
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	2 7; 9 2; 22 17; 29 12
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	5 10; 13 21; 22 6; 30 15
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	1 22; 8 2; 20 9; 26 13
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	4 17; 10 21; 23 6; 29 10
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	5 19; 13 4; 20 13; 27 22
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	5 8; 13 12; 21 17; 29 21
TX Scorpii	48.6	−34 13	7.5— 8.2	0 22.6	8 7; 15 20; 23 9; 30 22
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	3 3; 10 20; 18 14; 26 8
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	1 12; 9 11; 17 11; 25 11
WX Sagittae	53.6	−17 24	9.2—10.8	2 03.1	8 8; 16 20; 25 9
WY Sagittae	17 54.9	−23 1	9.5—10.6	4 16.0	1 3; 10 12; 19 20; 29 4
SX Draconis	18 03.0	+ 58 23	9.3—10.5	5 04.1	10 20; 21 4; 31 13
RS Sagittarii	11.0	−34 08	5.9— 6.3	2 10.0	7 0; 14 6; 21 11; 28 17
V Serpentis	11.1	−15 34	9.5—11.1	3 10.9	2 21; 9 18; 23 14; 30 12
RZ Scuti	21.1	— 9 15	7.4— 8.3	15 03.2	9 10 24 13
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	4 19; 11 23; 19 3; 26 6
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	1 4; 8 7; 22 12; 29 15
SX Sagittarii	39.7	−30 36	8.7— 9.8	2 01.8	9 0; 17 8; 25 15
RR Draconis	40.8	+62 34	9.3—13	2 19.9	1 22; 10 9; 18 21; 27 9
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	2 18; 9 9; 22 16; 29 8
β Lyrae	46.4	+33 15	3.4— 4.1	12 21.8	8 23 21 21
U Scuti	18 48.9	−12 44	9.1— 9.6	0 22.9	7 20; 15 11; 23 3; 30 18
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	6 14; 14 4; 21 18; 29 7
RV Lyrae	12.5	+32 15	11. —12.8	3 14.4	4 18; 11 13; 18 18; 25 22
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	4 5; 13 4; 22 3
U Sagittae	14.4	+19 26	6.5— 9.0	3 09.1	6 15; 13 9; 20 4; 26 22
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	5 3; 12 11; 19 20; 27 5
TT Lyrae	24.3	+41 30	9.4—11.6	5 05.8	2 10; 7 15; 18 3; 23 9
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	6 11; 12 23; 19 12; 26 0
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	3 0; 9 0; 21 0; 27 0
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	1 21; 8 12; 21 18; 28 9
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	7 20; 16 23; 26 3
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	9 4; 17 14; 26 1
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	7 5; 14 0; 20 19; 27 14
UW Cygni	19.6	+42 55	10.5—13	3 10.8	4 16; 11 14; 18 12; 25 9
V Vulpec.	32.3	+26 15	8.2— 9.8	37 19.0	
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	5 2; 14 17; 24 8
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	7 18; 16 23; 26 4
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	8 6; 15 18; 23 6; 30 17
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	2 3; 9 17; 17 8; 24 22
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	4 7; 14 10; 24 12
VV Cygni	21 02.3	+45 23	12.1—13.8	1 11.4	4 13; 11 23; 19 8; 26 17
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	7 20; 17 13; 27 5
RY Aquarii	14.8	−11 14	8.8—10.4	1 23.2	8 1; 15 22; 23 19; 31 16
RT Lacertae	21 57.4	+43 24	9.1—10.5	5 01.7	2 21; 13 1; 23 4
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3	27 12
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	6 12; 11 17; 22 1; 27 6
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.4	7 19; 16 2; 24 9
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.3	4 15; 12 4; 19 16; 27 5
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	4 13; 12 19; 21 1; 29 6

Maxima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5^h; Central standard time 6^h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1920. March							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7					26 0			
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	4 11;	12 14;	20 17;	28 21				
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	1 18;	9 11;	17 5;	24 23				
RW Cassiop.	130.7	+57 15	8.9—11.0	14 19.2	6 12		21 7					
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	1 22;	9 20;	17 19;	25 18				
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	5 19;	13 14;	21 9;	29 4				
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	4 11;	11 17;	19 1;	26 7				
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	1		17					
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	8 23;	17 13;	26 3					
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	9 17		20 20					
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0	12 9		24 0					
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	3 1;	10 16;	18 8;	26 1				
SY Aurigae	05.5	+42 41	8.4— 9.5	10 03.3	10 21		20 1					
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	5 23;	13 17;	21 11;	29 4				
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	4 12;	10 1;	21 2;	26 15				
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	6 20;	14 9;	21 23;	29 12				
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3			26 10					
RT Aurigae	23.0	+30 33	5.1— 6.0	3 17.5	1 7;	8 18;	16 5;	23 16				
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	2 1;	9 6;	23 16;	30 21				
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	1 14;	9 12;	17 10;	25 8				
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	4 13;	14 17;	24 21					
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5	1 19		24 1					
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	1 7;	9 6;	17 4;	25 3				
V Carinae	8 26.7	−59 47	7.4— 8.1	6 16.7	7 9;	14 2;	20 19;	27 11				
T Velorum	8 34.4	−47 01	7.6— 8.5	4 15.3	5 20;	15 3;	24 9					
V Velorum	9 19.2	−55 32	7.5— 8.2	4 08.9	7 0;	15 17;	24 11					
Z Leonis	9 46.4	+27 22	7.9— 9.6	59 00.0								
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	6 11;	13 12;	20 7;	27 2				
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	1 1;	7 15;	20 20;	27 11				
S Muscae	12 07.4	−69 36	6.4— 7.3	9 15.8	3 20;	13 11;	23 3					
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	1 6;	9 6;	17 5;	25 5				
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	2 15;	9 8;	22 19;	29 13				
R Crucis	18.1	−61 04	6.8— 7.9	5 19.8	6 0;	11 20;	23 11;	29 7				
S Crucis	12 48.4	−57 53	6.5— 7.6	4 16.6	1 9;	10 18;	20 3;	29 12				
W Virginis	13 20.9	− 2 52	8.7—10.4	17 06.5		13 8		30 14				
SS Hydrae	25.0	−23 08	7.4— 8.1	8 4.8	5 0;	13 5;	21 10;	29 15				
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	5 21;	12 22;	19 22;	26 23				
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	4 11;	12 16;	20 21;	29 2				
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	3 10;	14 9;	19 21;	30 21				
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	1 18;	9 7;	24 9;	31 22				
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	3 20;	11 6;	18 16;	26 2				
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	6 0;	12 19;	19 13;	28 8				
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	5 20;	12 3;	24 19;	31 3				
S Normae	16 10.6	−57 39	6.6— 7.6	9 18.1	8 14;	18 8;	28 2					
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	1 22;	10 18;	19 15;	28 11				
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	1 13;	7 15;	19 18;	31 21				
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	5 5;	12 6;	19 6;	26 6				
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9	6 19		23 22					
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	6 9;	13 23;	21 13;	29 3				
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	1 20;	13 9;	24 23;	30 17				
U Sagittarii	26.0	−19 12	6.5— 7.3	6 17.9	3 23;	10 17;	24 5;	30 23				
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	6 23;	17 7;	27 15					
Y Lyrae	34 2	+43 52	11.3—12.3	0 12.1	5 18;	11 19;	23 21;	29 22				
RZ Lyrae	18 39.9	+32 42	9.9—11.2	0 12.3	5 2;	11 6;	17 9;	29 15				

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1920. March							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h
RT Scuti	18 44.1	−10 30	9.1— 9.7	0 11.9	2 3;	8 1;	19 23;	25 22				
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	9 12;	18 15;	27 17					
U Aquilae	19 24.0	− 7 15	6.2— 6.9	7 00.6	7 22;	14 22;	21 23;	29 0				
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	2 20;	9 20;	23 20;	30 20				
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	3 18;	11 18;	19 17;	27 17				
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	2 7;	9 23;	17 16;	25 9				
η Aquilae	47.4	+ 0 45	3.7— 4.5	7 04.2	7 3;	14 7;	21 11;	28 16				
S Sagittae	51.5	+16 22	5.6— 6.4	8 09.2	1 11;	9 20;	18 5;	26 14				
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	2 14;	8 21;	21 13;	27 21				
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3	13 20		30 5					
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	4 7;	13 4;	22 1;	30 22				
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	2 16;	9 10;	22 21;	29 14				
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	5 14;	12 7;	19 0;	25 17				
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	4 11		19 5					
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	7 3;	15 0;	22 20;	30 17				
SW Aquarii	10.2	− 0 20	9.9—10.8	0 11.0	3 3;	10 1;	23 19;	30 17				
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	3 10;	8 17;	18 0;	27 17				
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.8	7 1;	15 16;	22 7					
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	2 8;	13 2;	23 20;	29 4				
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1	8 6;	19 3;	30 0					
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	4 4;	10 15;	23 11;	29 21				
V Lacertae	44.5	+55 48	8.5— 9.5	4 23.6	3 16;	13 15;	23 14;	28 14				
X Lacertae	22 45.0	+55 54	8.2— 8.6	5 10.7	1 16;	12 13;	23 11;	28 21				
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	5 16;	11 3;	22 0;	27 11				
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	11 6;	17 13;	23 20;	30 3				
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	9 23		22 2					
V Cephei	23 51.7	+82 38	6.0—7.0	0 23.9	5 23;	12 22;	19 22;	26 22				

COMET AND ASTEROID NOTES.

New Comet (Asteroid?).—A new comet was announced by cablegram as discovered by Comas Sola on January 13, 1920, and described as visible in a large telescope. The object was looked for with the 16-inch telescope at Goodsell Observatory on January 20 but could not be recognized with that instrument. Photographs taken with the 8-inch telescope and the 6-inch camera revealed the trail of an object like an asteroid of about the tenth magnitude. The trail in the 8-inch telescope was broken up by intermittent exposures into four measurable images, so that an accurate position could be obtained. On January 24 the object was found with the 16-inch telescope, by the aid of the photograph, and the position determined with the micrometer. The object shows no nebulosity at all and has exactly the appearance of an asteroid. The following are all the observed positions which have come to hand:

OBSERVATIONS.

G.M.T.	R.A.			Dec.			Observer	Place
	h	m	s	°	′	″		
Jan. 13.5011	8	06	44.0	+22	23	00	Comas Sola	Barcelona ?
20.6610*	7	57	40.50	+21	40	54.4	Wilson	Northfield
24.6455*	7	52	46.61	+21	16	27.1	Wilson	Northfield
24.8240	7	52	35.8	+21	15	08	Barnard	Williams Bay

* Mean place for 1920.0 uncorrected for aberration.

Ephemeris of Comet *c* 1919, (Metcalf-Borrelly).—The following ephemeris of Comet *c* 1919 is taken from *The Observatory* for December 1919. The comet cannot be seen by northern observers but may be followed by observers in the south temperate zone.

EPHEMERIS FOR GREENWICH MIDNIGHT

1920	R.A.			Dec.		log *r*	log Δ
	h	m	s	°	′		
Feb. 2	23	08	56	—33	06	0.1578	0.3349
6	23	25	24	32	30	0.1695	0.3418
10	23	41	18	31	48	0.1811	0.3490
14	23	56	42	31	03	0.1928	0.3564
18	0	11	31	30	13	0.2043	0.3641
22	0	25	46	29	20	0.2158	0.3718
26	0	39	28	28	25	0.2272	0.3800
Mar. 1	0	52	40	27	29	0.2383	0.3880
5	1	05	24	26	32	0.2493	0.3962
9	1	17	37	25	35	0.2601	0.4045
13	1	29	22	24	38	0.2707	0.4128
17	1	40	42	—23	41	0.2812	0.4211

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, December 1-20, 1919.

This report is necessarily shorter than the average because the change of date for mailing the lists shortened the month to twenty days. Now that the change has been made everything seems to be running very smoothly, and it is hoped that this will be of benefit to us.

The 1919 reprints are being mailed to each member, and those who fail to receive a copy should notify the recording secretary.

The President reports the receipt of many interesting and helpful replies to his circular letter of December 1, which was sent to each member. Such replies will serve to indicate the ways in which we can improve our efficiency, and it is hoped that those who have not yet replied will do so at the earliest possible opportunity. Already we are assured of numerous additions to our slide collection, and many offers of help and closer coöperation have been made.

The following have been recently elected to active membership by the Council:

Senor Numa Tapia, Observatorio Astronomica, La Plata, Argentina.

Mr. Charles J. Hudson, Worcester, Mass.

Mr. J. B. Roberts, Los Angeles, California.

The Association extends to Miss J. C. Mackie its hearty congratulations on the discovery of Nova Lyræ on January 6 of this year. This makes the third found by Miss Mackie within a year, and Miss Woods also has one to her credit, although too far south to be well observed from this latitude.

The distribution of telescopes to active members is being continued as opportunity offers, and we have recently been offered the use of one of the instruments at Amherst College.

Variable Star Observations, December, 1919.

Nov. 0 = 2422263 Dec. 0 = 2422293 Jan. 0 = 2422324

001046
X Androm.

J.D.	Est.	Obs.
242		
2294.6	<12.2	Pi

001620
T Ceti

J.D.	Est.	Obs.
2281.3	5.6	L

001755
T Cassiop.

J.D.	Est.	Obs.
2282.2	8.5	L
94.6	8.6	Pi

001838
R Androm.

J.D.	Est.	Obs.
2276.3	7.3	Pe
94.6	8.8	Pi
2307.6	8.7	Pt

004047
U Cassiop.

J.D.	Est.	Obs.
2303.6	<12.8	Y

004958
W Cassiop.

J.D.	Est.	Obs.
2294.6	9.2	Pi
2307.5	9.2	Gd

010940
U Androm.

J.D.	Est.	Obs.
2294.6	<11.8	Pi

011208
S Piscium

J.D.	Est.	Obs.
2308.6	13.	Y

012350
RZ Persei

J.D.	Est.	Obs.
2304.5	<12.6	Y

012502
R Piscium

J.D.	Est.	Obs.
2308.6	13.2	Y

014958
X Cassiop.

J.D.	Est.	Obs.
2294.6	11.1	Pi
2304.5	10.5	Y

015354
U Persei

J.D.	Est.	Obs.
2294.6	9.9	Pi

021024
R Arietis

J.D.	Est.	Obs.
2276.3	9.2	Pe
76.4	9.1	L
2303.3	10.6	
07.6	10.4	Hu

021403
o Ceti

J.D.	Est.	Obs.
242		
2275.3	7.1	Pe
76.3	6.2	L
91.3	7.3	Pe
2303.1	8.2	Mu_2
03.2	7.6	L
03.6	8.1	Pt
07.6	7.6	Ya
07.6	7.5	Hu
08.1	8.3	Mu_2

022150
RR Persei

J.D.	Est.	Obs.
2303.5	9.4	Pi
04.5	9.1	Y

022813
U Ceti

J.D.	Est.	Obs.
2308.6	12.6	Y

022980
RR Cephei

J.D.	Est.	Obs.
2281.3	<12.8	L

023133
R Trianguli

J.D.	Est.	Obs.
2307.6	7.0	Hu

024356
W Persei

J.D.	Est.	Obs.
2297.4	10.4	Cl
2303.5	10.4	Pi
07.6	9.7	Hu

030514
U Arietis

J.D.	Est.	Obs.
2303.6	<13.1	Y

032043
Y Persei

J.D.	Est.	Obs.
2273.2	9.6	Pe
2307.6	9.5	Pt
07.6	8.5	Hu

032335
R Persei

J.D.	Est.	Obs.
2303.6	9.3	Pi
07.6	9.0	Hu

032449
Nova Persei #2

J.D.	Est.	Obs.
2275.3	13.0	Pe

042209
R Tauri

J.D.	Est.	Obs.
2307.5	9.5	M
07.6	9.4	Hu
07.6	9.8	Pt
11.5	10.1	Y

042215
W Tauri

J.D.	Est.	Obs.
242		
2275.3	9.9	Pe
96.6	9.5	B
96.6	10.5	Cl
2307.5	10.1	M
07.6	9.5	Hu
08.6	10.2	Y

042309
S Tauri

J.D.	Est.	Obs.
2311.5	<13.	Y

043208
RX Tauri

J.D.	Est.	Obs.
2296.6	12.2	B

043274
X Camelop.

J.D.	Est.	Obs.
2296.5	<11.7	Pi
2308.5	13.	Y

044617
V Tauri

J.D.	Est.	Obs.
2311.5	<13.	Y

045307
R Orionis

J.D.	Est.	Obs.
2303.6	11.8	Y

045514
R Leporis

J.D.	Est.	Obs.
2266.6	8.9	L
97.3	9.1	
2307.6	8.5	Pt

050003
V Orionis

J.D.	Est.	Obs.
2303.6	12.1	Y

052034
S Aurigae

J.D.	Est.	Obs.
2266.3	9.2	L
96.6	8.3	B
97.5	9.2	Cl
2303.3	9.2	L

053005
T Orionis

J.D.	Est.	Obs.
2266.6	10.0	L
96.8	11.5	M
2307.6	11.0	Hu
13.7	10.2	E

053531
U Aurigae

J.D.	Est.	Obs.
2308.6	12.0	Y

054319
SU Tauri

J.D.	Est.	Obs.
242		
2281.3	9.4	L
96.6	9.5	B
96.6	9.4	Cl
97.5	9.2	
2303.3	9.5	L
07.5	9.5	E
07.5	10.1	Cl
07.6	9.4	M
08.6	9.4	Y
08.7	9.5	E
10.5	9.4	
13.7	9.5	

054615a
Z Tauri

J.D.	Est.	Obs.
2308.6	<12.8	Y

054615b
RS Tauri

J.D.	Est.	Obs.
2308.6	9.0	Y

054615c
RU Tauri

J.D.	Est.	Obs.
2308.6	12.8	Y

054920
U Orionis

J.D.	Est.	Obs.
2296.6	10.5	Cl
2307.6	11.4	M
07.6	10.9	Hu

054974
V Camel.

J.D.	Est.	Obs.
2308.6	13.	Y

055353
Z Tauri

J.D.	Est.	Obs.
2303.6	10.8	Pi
11.5	10.6	Y

060450
X Aurigae

J.D.	Est.	Obs.
2303.6	9.0	Pi
07.6	8.8	Pt
11.6	8.4	E

060547
SS Aurigae

J.D.	Est.	Obs.
2266.3	<11.6	L
76.4	<12.6	
79.4	<12.6	
80.3	<12.6	
81.3	12.2	
82.2	12.1	
89.3	10.7	
93.6	12.0	M
94.6	<12.4	Y
94.7	<12.4	Pi

SS Aurigae

J.D.	Est.	Obs.
242		
2295.3	<11.5	L
95.6	13.2	Jk
96.6	<13.0	B
97.6	<12.6	
97.6	<12.4	Y
2303.3	<12.6	L
03.4	<10.8	Jk
03.6	<12.4	Pi
03.7	<13.9	E
04.6	<10.8	Jd
07.5	<13.3	Cl
07.6	<12.4	Pi
07.6	<12.4	M
08.5	<13.3	Jk
08.7	<13.3	E
09.5	<12.3	Cl
10.5	<13.3	E
11.6	<13.3	
18.7	<13.3	

061647
V Aurigae

J.D.	Est.	Obs.
2296.6	9.6	B
2311.6	10.3	E

061702
V Monoc.

J.D.	Est.	Obs.
2296.8	10.5	M
2311.6	11.3	E

063159
U Lyncis

J.D.	Est.	Obs.
2307.6	13.3	Pi
08.6	<12.9	Y
11.6	14.5	E

063308
R Monoc.

J.D.	Est.	Obs.
2311.6	11.4	E

063558
S Lyncis

J.D.	Est.	Obs.
2307.6	13.0	Pi
11.6	<13.2	E

065111
Y Monoc.

J.D.	Est.	Obs.
2308.6	13.	Y

065355
R Lyncis

J.D.	Est.	Obs.
2308.6	<13.5	Y

070122a
R Gemin.

J.D.	Est.	Obs.
2291.4	7.1	Pe
2307.6	7.5	Pt
07.6	7.7	Pi

VARIABLE STAR OBSERVATIONS, December, 1919—Continued.

070122b
Z Gemin.
J.D. Est.Obs.
242
2291.4<12.1 Pe

070122c
TW Gemin.
2291.4 8.2 Pe

070310
R Can. Min.
2266.7 11.3 L
2307.6 10.4 Pi

072708
S Can. Min.
2291.4 10.3 Pe

073508
U Can. Min.
2308.6 12.8 Y

073723
S Gemin.
2307.6<12.4 Pi

074323
T Gemin.
2307.6 11.5 Pi

074922
U Gemin.
2266.6<13.3 L
94.7 10.4 Pi
95.8 11.1 M
96.6 12.5 B
96.6 12.5 Jk
96.8 12.0 M
2303.8<13.3 E
07.6<13.3 Pi
08.5<13.7 Jk
08.7<13.7 E
10.6<13.3
13.7<13.3
18.8<13.7

083350
X Urs. Maj.
2307.6 10.9 Pi

084803
S Hydrae
2308.8 10.4 E

085008
T Hydrae
2308.8 8.2 E

085120
T Cancri
2266.7 9.1 L
2308.8 8.8 E

090024
S Pyxidis
J.D. Est.Obs.
242
2308.9 9.2 E

090425
W Cancri
2266.7 8.5 L
2308.9 10.5 E

093014
X Hydrae
2308.9 11.9 E

093178
Y Draconis
2300.6 10.2 Y_2
08.6 10.0 Y

093934
R Leonis Min.
2266.7 10.7 L
2308.9 9.7 E

094023
RR Hydrae
2308.9 10.4 E

094211
R Leonis
2296.8 10.0 M
2308.9 10.2 E

094622
Y Hydrae
2308.9 7.3 E

095421
V Leonis
2308.9 13.4 E

104620
V Hydrae
2308.9 7.2 E

104814
W Leonis
2308.9 10.1 E

115919
R Com. Ber.
2308.9<13.2 E

120012
SU Virginis
2310.9 12.1 E

120905
T Virginis
2310.9 10.8 E

122001
SS Virginis
2310.9 7.0 E

122532
T Can. Ven.
J.D. Est.Obs.
242
2310.9 11.7 E

122803
Y Virginis
2310.9 13.2 E

123160
T Urs. Maj.
2296.8 8.4 M
2310.4 9.1 Jk
18.9 9.6 E

123307
R Virginis
2310.9 8.2 E

123459
RS Urs. Maj.
2318.9<13.6 E

123961
S Urs. Maj.
2280.2 9.1 L
96.8 10.3 M
2310.5 10.9 Jk

124204
RU Virginis
2310.9<12.8 E

124606
U Virginis
2310.9 12.7 E

125705
RT Virginis
2310.9 8.3 E

140512
Z Virginis
2318.9 11.3 E

141954
S Bootis
2280.2 12.5 L

142539
V Bootis
2280.2 9.5 L

154428
R Cor. Bor.
2272.2 6.1 L
80.2 6.0
2306.9 5.9 Pt

163137
W Herculis
2303.5 10.8 Jk

163266
R Draconis
J.D. Est.Obs.
242
2303.5 12.2 Jk

164055
S Draconis
2307.6 9.0 Pt

175458a
T Draconis
2303.5 12.0 Jk

175458b
UY Draconis
2303.5 11.2 Jk

175519
RY Herculis
2273.2<11.7 Pe

180531
T Herculis
2276.3 11.3 Pe
79.3 11.8 L
97.5 12.6 B

180565
W Draconis
2303.5<12.0 Jk

180911
Nova Ophiu. #4
2289.3 9.3 L
97.2 8.7
2300.2 8.3
03.2 8.5
03.5 8.9 Jk

181136
W Lyrae
2276.3 7.4 Pe
77.5 7.8 Y
79.3 8.1 L
97.2 8.3
2307.5 8.1 Pt
09.5 8.6 Y

182224
SV Herculis
2273.2 10.8 Pe
76.3 10.9
80.3 10.6 L
97.5 11.9 B

183149
SV Draconis
2309.5<12.6 Y

183225
RZ Herculis
2309.5<12.2 Y

183308
X Ophiuchi
J.D. Est.Obs.
242
2280.2 8.7 L

184205
R Scuti
2266.3 5.4 L
72.2 5.5
73.2 5.6 Pe
80.2 5.4 L
89.3 5.9
95.6 5.7 Pt
97.2 6.0 L
97.6 6.0 Pt
2301.6 5.9 Mu
03.2 6.1 L
06.6 5.9 Mu
07.5 5.7 Pt

184300
Nova Aquilae #3
2272.2 8.0 L
73.2 8.0 Pe
95.6 7.4 Pt
97.6 7.4
2307.5 7.5

190108
R Aquilae
2297.5 6.6 B

190529
V Lyrae
2309.5<12.5 Y

190925
S Lyrae
2279.4 12.0 L
2303.2 11.7

190967
U Draconis
2311.6 12.0 Hu

191033
RY Sagittarii
2272.2 6.1 L

191350
TZ Cygni
2304.5 10.6 Y

193449
R Cygni
2307.5 9.0 M

193732
TT Cygni
2311.6 8.0 Hu

VARIABLE STAR OBSERVATIONS, December, 1919—Continued.

194048 RT Cygni			200938 RS Cygni			*204405* T Aquarii			213843 SS Cygni			*225120* S Aquarii		
J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
242			242			242			242			242		
2307.5	8.4	M	2275.3	8.4	Pe	2297.5	12.6	B	2296.6	11.6	B	2311.5	12.5	Y
07.5	8.2	Pt	97.3	7.8	L				97.3	11.8	L			
11.6	8.5	Hu	2307.5	8.4	M	205933 R Vulpeculae			97.5	12.0	Cl	225914 RW Pegasi		
						2307.5	11.2	M	97.6	11.7	B	2297.6	11.6	B
194348 TU Cygni			201008 R Delphini						2300.5	11.7	Cl	2309.5	11.2	Y
2307.5<12.1 M			2272.2<11.8 L			*210116* RS Capric.			00.8<10.9 Jd					
						2303.5	8.1	Ya	03.3	11.9	L	230110 R Pegasi		
194632 χ Cygni			*201121* RT Capric.			07.5	8.6	Pt	03.5	12.0	Pi	2276.3	12.1	Pe
2275.3	12.7	Pe	2280.2	7.4	L				03.5	11.6	Jk	91.4	11.8	
2311.6<12.0		Hu				210129 TW Cygni			04.5<10.9		Jd	2311.5	10.3	Y
			201130 SX Cygni			2304.5	12.5	Y	04.5	11.5	Cl			
195849 Z Cygni			2304.5	8.2	Y				04.5	11.6	Y	230759 V Cassiop.		
2276.3	12.9	Pe				210382 X Cephei			07.4	11.9	Gd	2294.6	11.7	Pi
2303.5	12.5	Pi	201647 U Cygni			2311.5<13.4		Y	07.5	12.0	Cl			
07.5	12.0	M	2276.3	8.0	Pe				07.5	12.1	M	231508 S Pegasi		
			2303.5	8.2	Pi	210868 T Cephei			07.6	11.8	Pi	2276.3	8.3	Pe
200212 SY Aquilae			03.6	7.6	Ya	2276.3	7.3	L	08.5	12.1	Jk	91.4	8.2	
2280.2<13.0		L	07.5	8.1	Pt	97.2	7.1		09.5	11.6	Cl			
						2307.5	8.1	Pt	09.5	11.6	Y	233335 ST Androm.		
200357 S Cygni			202539 RW Cygni						09.6<10.9		Jd	2294.6	10.4	Pi
2303.5<12.4		Pi	2307.5	9.2	M	211614 X Pegasi			10.5	11.6	Jk	97.6	10.0	B
						2304.5	11.7	Y	11.5<10.9		Jd	2307.6	10.2	Pt
200647 SV Cygni			202946 SZ Cygni						11.5	11.6	Y			
2311.6	8.0	Hu	2307.5	9.6	M	213244 W Cygni			11.6	12.0	Hu	*233815* R Aquarli		
						2291.3	6.2	Pe				2303.6	7.1	Pt
200715a S Aquilae			202954 ST Cygni			97.3	5.2	L	213937 RV Cygni					
2303.5	9.6	Ya	2304.5<13.		Y	2303.3	5.4		2307.5	8.2	M	*235209* V Ceti		
									07.5	7.9	Pt	2281.3<12.7		L
200715b RW Aquilae			203226 V Vulpeculae			213678 S Cephei			11.6	7.6	Hu			
2307.5	9.3	Ya	2307.5	9.5	Pt	2297.6	8.5	B				235350 R Cassiop.		
			07.6	9.0	M				215605 V Pegasi			2294.6	11.2	Pi
200906						213843 SS Cygni			2311.5<13.		Y			
Z Aquilae			203816 S Delphini			2273.4	10.8	L				235939 SV Androm.		
2297.5	10.7	Cl	2311.6	8.7	Hu	91.3	11.6	Pe	215934 RT Pegasi			2294.6	8.5	Pi
97.5	11.7	B				94.6	11.6	Cl	2304.5	10.3	Y	2310.4	8.6	Jk
			204104 W Aquarii			94.6	11.8	Pi						
200916 R Sagittae			2276.3<11.3		L	96.5	11.8		222439 S Lacertae					
2303.5	9.1	Ya				96.6	11.7	Cl	2277.9	11.1	L_2			
									94.6	11.4	Pi			
									97.6	12.0	B			
									2311.5	12.4	Y			
									223841 R Lacertae					
									2311.5	9.5	Y			

No. of Observations: 368. No. of Stars Observed: 163. No. of Observers: 15.

The following members contributed to this report: Messrs. Bouton, Clement, Eaton, Godfrey, Hunter, Jordan, Lacchini, McAteer, Mundt, Peltier, de Perrot, Pickering, Yalden, and Misses Jenkins and Young.

HOWARD O. EATON, Recording Secretary.

GENERAL NOTES.

Professor Elia Millosevich, director of the royal observatory at the College of Rome, died on December 6, 1919, after a brief but severe illness, at the age of 71.

The following tribute to Professor Millosevich by his friend Pio Emanuelli is translated from the *Cronaca di Roma* for December 6.

"This is a great loss for science and a most grievous loss for all who knew intimately this man of lofty moral sense, of unlimited goodness; whose mind was freely open to all the noblest and purest virtues. He was one of the greatest astronomers, certainly the best known, of Italy.

"Born September 5, 1848, his father being of Cattaro, young Millosevich began his glorious scientific career in a humble station, in the postal service at Venice, where he had to provide for himself and his family. He was a real self-made man, rising without favors, without class prestige, but only by virtue of long study and his great love for science.

"At the age of 23 he won the chair of Nautical Astronomy in the Royal Institute of the Mercantile Marine at Venice, where he founded a small observatory. Some time after, he left Venice to take charge as vice-director of the Central Office of Meteorology and Geodynamics in Rome, and of the Astronomical Observatory of the College of Rome.

"To enumerate his publications would be a very long task since they number several hundred, appearing in various local and foreign scientific periodicals. He was an astronomical calculator without a peer and computed the orbits of several planets and comets, and not a few eclipses. His studies of the planetoid Eros made it possible for the astronomers of the world to determine the distance from the Earth to the Sun with great precision. He prepared two star catalogues and occupied himself also with chronology. He proved by comparison of lunar eclipses with ancient chronicles that the birth of Christ occurred four years earlier than according to the Dyonisian calculation.

"He was a member of a large number of Italian and foreign societies and received several signal honors, among which was the royal prize in Astronomy of the R. Accademia dei Lincei, of which he was secretary."

The Eclipse of May 29, 1919, at La Paz, Bolivia.—In his annual report for 1919, Director Abbot of the Smithsonian Astrophysical Observatory gives an interesting account of the expedition sent by the Smithsonian Institution to observe the solar eclipse at La Paz, Bolivia. The altitude of the station was about 14,000 feet above sea level. The total phase of the eclipse occurred only 20 minutes after sunrise, yet successful observations and excellent photographs were obtained. Dr. Abbot's description of the phenomenon, which follows, is exceedingly interesting:

"The phenomenon was uncommonly grand, far more so than appears in the photograph. The sun had risen over a snow-capped mountain, about 20,000 feet high. It rose over half eclipsed, with the crescent horns pointing upward from the horizon equally. In 20 minutes totality occurred, and there shot out over 20 fine sharp coronal rays, greatest elongated along the equatorial zone, but also visible to great distances from the poles. At the lower limb there was a very

large flaming red prominence, which at that time rose to perhaps a quarter of the solar radius, and had a very long side extension, after the manner of a hook. The same prominence was observed by spectroscopic methods in the United States, at the great observatories, and was one of the finest prominences ever photographed. It is very interesting and fortunate that the early history of this prominence was enriched by the photograph made at La Paz so very early in the morning.

"Taking the whole phenomenon together, the snow-covered mountain, the brilliant sky at that great altitude of 14,000 feet, the very numerous and long coronal streamers, and the enormous crimson prominence casting its glow over all, the spectacle was truly glorious, and by far the most impressive of any of the eclipses which have been seen by the writer. It was reported that the Bolivian natives lighted many fires and supplicated the sun to return, after old Inca traditions."

A New Star.—Miss Mackie has found another New Star in the course of her examination of the Harvard photographs of the Milky Way. Its position is, R.A. $18^h\ 49^m\ 30^s$, Dec. $+29°\ 6'3$ (1900). Miss Cannon finds that it has the characteristic spectrum of the early Nova type. Between December 4 and 6 it rose rapidly from the sixteenth magnitude or fainter, to a maximum of about 6.5. Since that time it has undergone marked fluctuations in brightness. Its present magnitude is 8.5.

Photographs with large instruments are needed, to determine the detailed characteristics of its spectrum. The star is now far to the west in the evening but will soon be accessible in the early morning.

S. I. Bailey.

Harvard College Observatory Bulletin 705,
Cambridge Mass. U. S. A., January 6, 1920.

A Graphical Representation of Geologic Time.—Mr. Arthur Hollick, in the *Scientific American*, January 10, 1920, gives a description of a rather ingenious representation of geologic time. He draws upon a chart the dial of a clock representing the age of the Earth, or the cosmic day. The dial is divided into 24 hours, hence each hour is equivalent to three million years of geologic time, if we assume the age of the Earth to be seventy-two million years, which is somewhere near the average estimate now made by geologists.

"The estimates of the geologic time ratios are to the effect that Pre-Paleozoic, Paleozoic, and Mesozoic time are respectively twelve, eight and three times the duration of Neozoic time, in which we live today. If these ratios are applied to the hour divisions of the clock dial we have:

Pre-Paleozoic time,	12 hours	=	36,000,000 years
Paleozoic time,	8 "	=	24,000,000 "
Mesozoic time,	3 "	=	9,000,000 "
Neozoic time,	1 "	=	3,000,000 "

By subdividing each of the time divisions into its appropriate geologic periods the approximate antiquity of each period is indicated.

"The even subdivision of Pre-Paleozoic time into Azoic and Eozoic is purely arbitrary, as is also the indicated time duration of the several geologic periods, except in connection with the Quaternary, which is assumed to include the last 500,000 years of cosmic time, equivalent to the last ten minutes of the twenty-

fourth hour, and to represent the time that has elapsed since the appearance of man; and if any one should wish to indicate the historical period of human affairs it would be represented approximately by the final twelve seconds of the dial."

The Reflecting Power of Fog.—From Director Abbot's annual report on the Smithsonian Astrophysical Observatory for the year ending June 30, 1919, we learn that in September 1918 experiments were made at Arcadia, at the foot of Mount Wilson, to determine the reflecting power of the upper surface of the great layer of fog which often covers the San Gabriel and other valleys in a sheet of many miles in extent. The experiment was made possible by the coöperation of the Army Balloon School at Arcadia.

A pyranometer was hung below the basket of a captive balloon about 200 feet above the layer of fog. An officer of the balloon school exposed the apparatus under the balloon to the radiation from the sheet of fog, while Mr. Aldrich, on the ground, observed the deflections of the galvanometer, which was connected with the pyranometer by a pair of wires about a half mile long. On this occasion the fog extended from 1000 to 2500 feet of altitude. The result of the experiments, which were continued for several hours without interruption, was very satisfactory, yielding a final value of 78 percent for the reflecting power of a great horizontal sheet of fog.

A Method of Reaching Extreme Altitudes.—This is the title of an important paper by Robert H. Goddard, of Clark College, Worcester, Massachusetts, which has just been issued as Smithsonian Miscellaneous Collections, Vol. 71, No. 2. Mr. Goddard has been investigating the feasibility of sending recording meteorological instruments up to extreme altitudes by means of specially designed rockets, for the purpose of studying conditions in the upper layers of the earth's atmosphere which are beyond the reach of sounding balloons.

Experiments with ordinary rockets show that the efficiency of such rockets is of the order of 2 percent, and the velocity of ejection of the gases 1000 ft./sec. With a special type of steel chamber and nozzle, an efficiency has been obtained with smokeless powder of over 64 percent (higher than that of any heat engine ever before tested), and a velocity of nearly 8000 ft./sec., which is the highest velocity so far obtained in any way except in electrical discharge work.

Experiments repeated with the same chamber in vacuum gave slightly higher velocities than the air, showing that the velocity is not merely due to the reaction of the gases against the air.

Theoretical calculations based on the results of the experiments indicate that it is feasible, by means of specially constructed rockets, with a number of chambers to be discharged at successive intervals, to project a mass of one pound to the extreme upper atmosphere without destroying the carried apparatus by the effect of concussion.

In fact, Mr. Goddard indicates that it would be possible, without involving inordinate expense, to send a charge of powder to the moon, of such size that the flash of its discharge there might be visible on the earth. The total initial mass of the rocket necessary for this would only be from 8 to 10 tons.

The newspaper reporters are making much more of Mr. Goddard's statements than he would probably vouch for, but it really begins to seem as if another of Jules Verne's fictions were not so far from possible truth as it appeared in his day.

Composition of Volcanic Gases.—A recent brief paper by Mr. E. S. Shepherd, of the Carnegie Geophysical Laboratory, presents preliminary results of the analysis of gases collected from the lava lake of Kilauea and calls attention to the important work of this character now in progress there under the direction of Dr. Jaggar. The matter ejected from a volcano is of special interest as tending to throw light upon the sources of volcanic energy. Abundant information has been collected concerning the composition of lavas, but little concerning the gaseous emanations of volcanoes. The difficulties of collecting such gases are naturally very great. Of the three attempts at such collections made by expeditions of the Geophysical Laboratory at Kilauea, only that of 1917 yielded samples satisfactory for quantitative study. In that case vacuum tubes with a soft glass plug at one end were wired to bamboo rods and the fusible end was inserted into promising flame holes as the lava crusts swept along the edge of the lake. Dr. Jaggar, who is permanently in residence at the Hawaiian Volcano Observatory, is now collecting gas samples systematically, and Mr. Shepherd believes that these samples will give us for the first time the data needed to establish definitely the relative importance of the various suspected sources of volcanic energy. (*Scientific American,* January 10, 1920.)

A New Popular Scientific Journal.—A New Popular Scientific Journal, to be known as *Discovery,* will be launched in England in January, 1920, under the aegis of the leading British scientific and educational organizations. It is to be edited by Capt. A. S. Russell, lately appointed reader in chemistry at Christ Church, Oxford. The new journal will, aim to present, in brief monthly form, the progress of knowledge in all its chief branches. The project of establishing a similar authoritative journal in the United States, under the auspices of the American Association and the National Academy of Sciences, has been agitated for the past two years, and will, it is hoped, soon come to fruition. (*Scientific American,* January 10, 1920.)

Herschel. By the Rev. Hector Macpherson, M. A., F. R. A. S., F. R. S. E. Published by the Society for Promoting Christian Knowledge, London, and the Macmillan Company, New York. Price 2 shillings net, in paper 1 shilling.

This little book of 75 pages is one of a series on Pioneers of Progress, Men of Science, edited by S. Chapman and published by the Society for Promoting Christian Knowledge, 6 St. Martin's Place, London W. C. 2. Sir William Herschel is rightly chosen as a "pioneer of progress" in astronomy and the author selected is one of the most interesting of English writers on astronomical subjects. One can easily read the book through in a couple of hours and cannot but gain a high appreciation of the character and work of a wonderful man, and an inspiration to study the subject which he did so much to promote.

The book is illustrated with a well reproduced portrait of Herschel from a picture in the National Portrait Gallery.